Reductionism in Psychology

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Abstract

Reductionism in psychology is traditionally regarded as an exercise in drawing data from a physiological field in order to explain psychological or behavioural phenomena. The data taken from the physiological level are seen in this view as more basic and more real in terms of a hierarchy of sciences, and come closer to providing "hard facts" due to physiology lying lower on a hierarchy of sciences than psychology.

However, reductionism is also considered here in a number of different ways, including: 1) the breaking down of wholes into parts in science; 2) reduction to disciplines such as mechanics or computing through modelling; 3) reduction "upwards" to higher levels than psychology; 4) single concepts in psychology; and 5) individualism as a reductive outlook.

The hierarchy of sciences is critiqued in terms of indeterminacies that prevent the lower-level sciences from fully constituting the higher-level sciences. A "downwardly determinative" outlook is endorsed which sees the contents of lower-level sciences as being distributed or guided by the systems that the higher-level sciences represent. Non-specific precipitants at higher levels are seen to control the more widely distributed but more specialised phenomena at lower levels, and a twin-aspect theoretical outlook is endorsed which sees a given unit of analysis as being a whole in itself and part of a larger system.

The implication of this for reductionism in psychology is that whilst an elimination of psychological terms in favour of physiological terms is rejected, explanations that include physiology in a complementary role may have some value, although such contributions may appear insignificant in the light of the higher-level concepts that flow down to psychology from higher level disciplines.

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CHAPTER ONE

Introduction

Reductionism in science is an issue that underlies the whole concept of a hierarchically ordered world. The problem of whether one level of knowledge can be reduced to another level has implications for a diversity of questions such as what constitutes a sufficient explanation, can the sciences be autonomous from each other, to what extent are the phenomena of the world mechanically determined, and the question of how the empirical world gains its credibility.

Reductionism is now no longer regarded as a complete belief-system in itself that enables sufficient description or explanation of the workings of the world (Wimsatt, 1979), and the reductive faith that holds that any irreducibility between levels of systems or theories is due to deficits in the technological sophistication of the current research era has diminished somewhat, replaced by a scepticism which places the onus upon the reductive philosophy and method to prove itself. Reductionism in science can be seen as a question that is central to the philosophy of science (Vollmer,1984), and questions regarding the adequacy, nature and place of reductive theorising in psychology are a major concern of this thesis.

Reductionism in psychology appears to be a legacy of the positivistic mode of science that psychology borrowed from the natural sciences such as physics and chemistry. As a general rule, wholes are broken down into parts and the parts are studied. A more common conception of reductionism in psychology is of the translation problem between sciences or levels of analysis, usually psychology and physiology (biology). However, reduction occurs in the scientific process in a number of different ways, and the first part of this chapter will present a list of several different processes that the terms "reduction" or "reductionism" can refer to. Although it has a wide scope, the list should not be considered exhaustive.

This dissertation is a result of seeing the scientific process in two ways: 1) As a linguistic process; and 2) as an observer and manipulator of stuff, .i.e. real things, albeit through theory. A perspective that sees reductive science as a result of academic publication pressures is also interesting but beyond the scope of this thesis. Here then is a list of six different types of reductive strategy in psychology:

1) Reduction from psychology to physiology

(including neurophysiology).

2) Reduction to other disciplines such as economics and computing through modelling. Single concepts on psychology.

3) Reduction of societal level phenomena to the level of the individual (individualism).

5) Reduction "upwards" from psychology to higher order phenomena.

6) The breaking down of wholes into parts.

The literature on reductionism that this thesis attempts to represent covers the field of reduction or reductionism (these two terms will be used interchangeably) in a number of different ways, some of which are indicated in the six types of reductive strategy outlined above. A soft-focus indication of the main message that comes across in this thesis is that reductionism is an issue that goes beyond the linguistic problems of translating one scientific language or terminology into another; the reductive programme encourages a way of dealing with concrete worldly phenomena that sees scientists breaking down wholes into constituent parts and studying the parts regardless of whether or not the terms translate or the higher-level meaning remains intact. Explanation consists of reducing a subject of science to its constituent parts, which are considered to contain the essence of understanding the target phenomenon. Thus in spite of the presupposition of hierarchical order, the constituent parts are studied. The gross properties of higher-level entities are then deduced or extrapolated from the more fundamental entities and processes (Robinson, 1986). The term "unit of analysis" is used in this thesis to refer to the nature of the content of a given science or discipline - the size or scope of this unit is an important factor and indicates the level of science the unit lies at.

Such a wide-ranging literature provides difficulties in the integration of the work of different people saying the same things in different ways.The topic of reductionism is relevant to discussions on the mind-body problem, consciousness, linguistic work on translation problems between different scientific and natural languages, wholes, sums and parts, individualism and the problem of the organism in psychology. Thus some attempt is made here to cover a wide range of material. There is also the conflict in this thesis between precise, repetitive, parsimonious language and the more interesting but less precise practise of saying something in a new way every time. Given the theoretical nature of the dissertation and the resulting implications for freedom of expression, some license is taken when jargon terms threaten to bore the reader. For example, the second word of the phrase "reductive strategy" could be replaced by any of the following words: analysis, philosophy, outlook, programme, methodology, method, paradigm, epistemology, ontology, science or persuasion.

The scientific community that uses

reductionism as its method and philosophy of action is the subject of study in this thesis, but this is not a dissertation on scientific method itself. A major concern here is on the knowledge framework that reductionism operates in - this thesis talks about things that happen even before the empirical work starts. The reductive way of interpreting the world influences the results of data collection before the data are taken. The objective is not, therefore, to suggest improvements on scientific method, but to develop a plausible or more realistic theoretical framework that better represents an assumed complexity between levels of systems in science.

Summary of Chapters

Chapter Two examines the atomistic method that follows from the reductive framework of positivistic science. The emphasis is on an explication of the neural structures that are studied in physiological psychology. The structure and function of the basic neuron is outlined in some detail in order to present in sharp focus the all-or-none firing mechanism that is held in reductionist circles to carry the burden of psychological content. The aggregate properties of clusters of millions of neurons are discussed, along with the emergent properties that appear as a result of such aggregation.

Chapter Three examines the difficult topic of explanation in science and psychology, and attempts to relate causation with description and explanation. Explanation is seen to be carried out through theory, and the theory-dependent nature of observations is stressed.

Chapter Four continues the theme of explanation in psychology, with reference to the different levels of science from which explanatory information can be sought. The concept of levels of science is critiqued, and a hierarchy of systems is also outlined.The unit of analysis for psychology in the light of this hierarchy of systems is discussed, and a twin-aspect theoretical outlook is proposed that sees scientific phenomena as being wholes in themselves and also part of a larger system, an outlook which attempts to avoid certain problems of either a "top-down" approach or a "bottom-up" approach.

Chapter Five tackles the issues in translation between sciences, and discusses three different views of reduction in psychology, namely "eliminative-reduction", "derivation-reduction" and "model reduction". Whilst the eliminative view is rejected in favour of a derivational approach, Chapter Five is largely concerned with presenting a derivational approach that fits in with the framework developed in Chapter Four.

The Conclusion attempts to synthesise the aspects of reduction that were broken down into the constituent chapters, with an emphasis on a theoretical outlook that sees the subject matter of science as being best represented by the twin-aspect approach outlined in Chapter Four.

CHAPTER TWO

Reduction to Physiology

Introduction.

Reduction to physiology is the concern of the psychological reductionist, since physiology is the next lower science on a hierarchy of sciences that runs from physics near the "bottom" through to sociology near the "top". This type of reductionism is one on which a whole field of research is based-physiological psychology. Journals servicing this field include the *Behavioural & Brain sciences, Behavioural Biology, Psychopharmacology,* and *Psychophysiology.* Reducing psychological phenomena to the biological level often involves changing the nature of the explanatory variable from some sort of psychological phenomenon to a previously unsuspected physiological phenomenon. This does not necessarily mean that the problem is seen as "nothing but" systems or processes at the lower level, although it is the favoured option. It is taken here that the psychological concept that is of greatest interest to the physiological psychologist is behaviour. Thus reduction in psychology involves reducing behaviour to physiology. The treatment of bodily functions (such as motor movement) as physiological questions is also studied but is more within-level and has more tenuous links with psychology. The replacement of psychological with physiological explanations is also an option. Two theoretical views on reduction, eliminative-reduction and derivation-reduction (after Clarke, 1980) will introduce different ways of interpreting what is seen here as the same methodological task. Clark has a third view, model-reduction, that is discussed in Chapter Five.

The two types of reduction outlined above described by Clarke (1980) are:

1) Eliminative-reduction; This type of reduction follows from a replacement assumption that for a theory A to reduce to reduce to a theory B, then the sentences of theory A must in all cases be successfully replaced by the sentences in theory B . Theories do not have to be expressed in sentential form. Thus when a successful reduction is made, the terms of the more fundamental science leave no room for the terms of the higher level science.

2) Derivation-reduction; The reducing theory does not replace or render irrelevant the reduced theory, it merely provides a

second set of explanations for the same phenomena. The reducing theory explains why the laws of the reduced theory hold (Clarke,1980). Reducing laws in this type of reductionism complement the laws at the higher level.

Clark regards theories as sets of sentences useful for explaining phenomena. Treating theories as a linguistic phenomenon renders the problem of reductionism an exercise in the logical relations between the theories at different levels. If the sentences of different levels can be logically derived from the sentences of a reducing theory, then a successful reduction has taken place. However, there are also methodological considerations regarding reductionism that are important to mention, namely that a reductionist theory facilitates a scientific method that involves measuring the physiological states of the organisms under study. This can be carried out to a point where linguistic translation problems between sciences can almost, but not quite, be ignored. As mentioned before, it is these methodological considerations that are of chief interest in this chapter.

What is Reduction to Physiology?

Reduction to physiology involves, amongst other things, identification of neural states as mental processes, and as determinants of behaviour. This section starts by exploring the relationship between mental states and neural states.

Mental states or processes are considered here to be the same thing as the "mind", with the latter being a rather more vague term. Valentine (1982) listed mental phenomena to include sensations, images, thoughts, beliefs, intentions and decisions.

After the Copernican revolution in science, causes of worldly phenomena came down out of the heavens and into the natural world (Koestler,1959). Progress in physics and chemistry carried the message that worldly phenomena could be explained with reference to other worldly phenomena at a different, lower level. Newton proposed a force that accounted for the tendency of objects to fall, and even explained why some objects fall faster than others. In medicine, a circulatory system emerged, eliminating the need for a celestial source of a continual supply of blood. After the discovery that the brain had some role to play in behaviour and bodily function, it eventually became clear that the brain was not an undifferentiated unit, and some localisation of function was possible regarding bodily function. Localisation of function with regard to behaviour became increasingly evident, with the encapsulation of the mind in the brain being a logical progression. Thus the scientific answer to the question "what are mental states" became one that increasingly, if not exclusively, referred to neural states.

The scientific, reductionist interpretation of the neural nature of mental processes involves an implicit endorsement of a particular view of the mind-body problem. This

view is known as the monist-materialist view (Marx & Hillix, 1979), although other orientations can be fitted into a reductionist framework. This view encompasses a simple philosophy which sees mental events as neurophysiological events or processes occurring in the brain (The term "neurophysiological events" will be condensed where possible to "neural states"). From this perspective the mind is not a mystic or intangible thing, but a physical entity localized in the brain area. Otherwise known as physicalism, this extreme materialist interpretation of the mind-body problem is quite consistent with a reductionist outlook. However, physicalism, as mentioned earlier, is not the only interpretation of the mind-body problem that is consistent with reductionism. Other views can be reconciled with reductionism (e.g. psychophysiological parallelism), and given that bodily neural states exist, one could probably reconcile almost any orientation to the mind-body problem with reductionism. The purpose in mentioning the mind-body problem then, is to point out the materialistic, atomistic orientation implicit in much scientific work. The next section analyses the atomistic method in some detail.

Neural States: The Basic Neuron.

The neuron, known as the "basic unit of the nervous system" (Levinthal, 1979) is able to receive and transmit signals (figure one), thus facilitating communication between different parts of the body. A human brain contains approximately ten billion neurons. The signals that the neurons transmit are electrical, although the transmission between neurons is better understood as electrochemical in nature.The neuron has three main components - the soma, the dendrites and the axon. An impulse is received by the dendrites through the synaptic clefts. It travels, in most cases, through the cell body, and along the axon as a single process. At the furtherest end, the axon branches out out to several small end points called terminal boutons or buttons. The area of interest here as will be seen, lies in the activity at the synapses, therefore a short outline of the activities in the synaptic clefts is appropriate.

The Synaptic Cleft.

The structure and process is somewhat complicated and bears some explaining. Briefly, the firing axon sends a message to the terminal buttons and a number of synaptic vesicles (bags of neurotransmitter) move to a presynaptic membrane, adhere to it, and then rupture, with the contents being released into the synaptic cleft. The synaptic cleft is a minute gap between the presynaptic and postsynaptic membranes, across which the neurotransmitter travels in order to stimulate the postsynaptic receptors that send signals to converge on the axon hillock (figure two). If the "action potential is propogated", then the neuron can "fire".

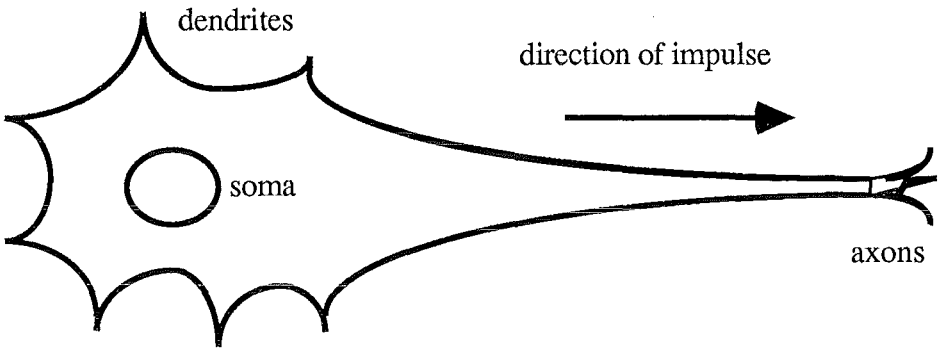

Figure one. Drawing showing the three main components of the neuron.

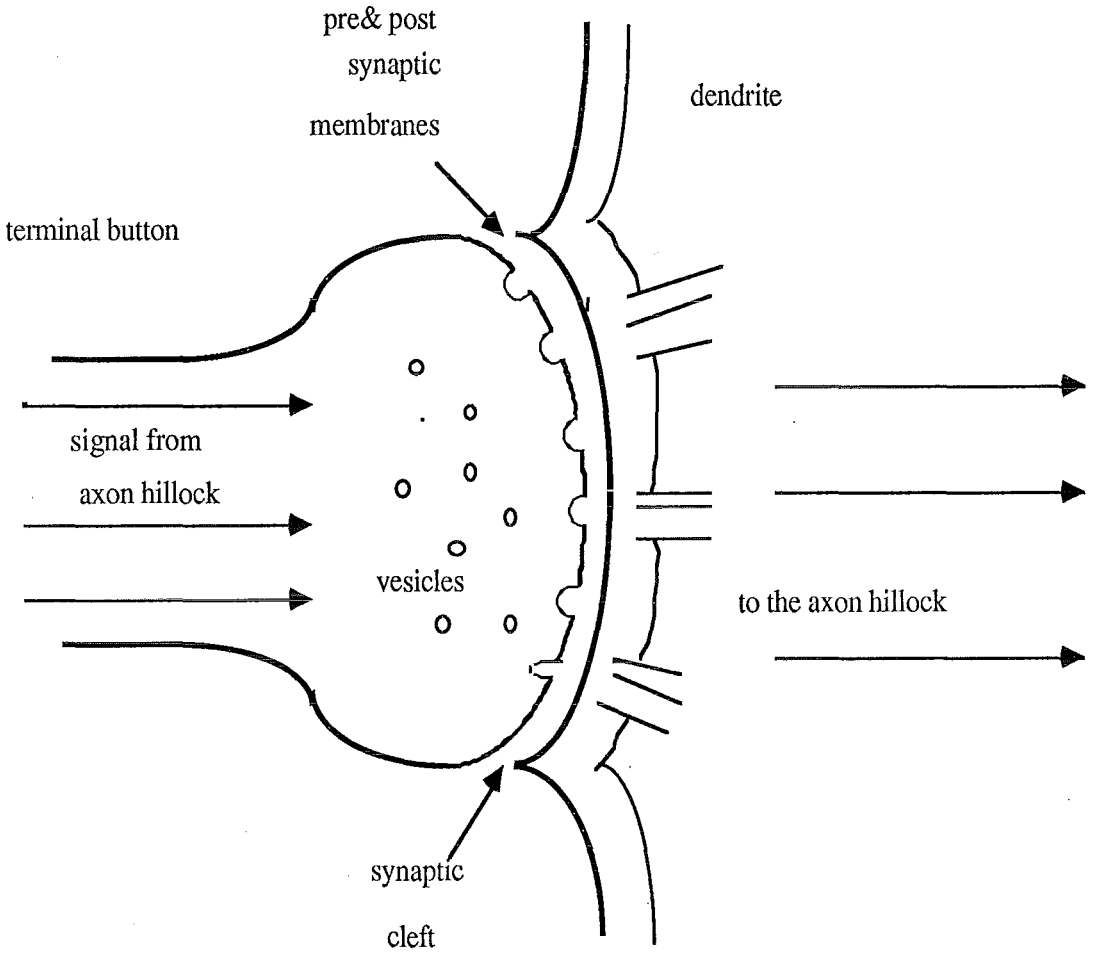

Figure two. The synaptic cleft.

The movements of neurotransmitters are closely involved with the electrical valences that surround the presynaptic and postsynaptic membranes. For example, neurotransmitter is released by the sudden reversal of charges on either side of the membrane. This reversal of charges is due to the exchange of positively and negatively charged elements through the membranes.

The neuron is found throughout the nervous system, and has a remarkably simple function. A neuron that is at rest does not transmit any information. A neuron that is "firing" receives and transmits a single impulse. The concept of the threshold is important here. A neuron needs to receive a signal of sufficient strength to enable it to pass the signal on. A "weak" signal may result in the failure of the next neuron to fire. The signal can break down at any stage.

For example: 1) The weak signal may result in insufficient quantities of neurotransmitter being released into the synaptic clefts; 2) the receptor membranes may receive insufficient quantities of neurotransmitter and fail to be properly stimulated; 3) The dendrites may send an insufficient number of signals to the axon hillock for the neuron to fire.

These three examples indicate three places in the causal chain where the the signal can break down. The third example, the situation where not enough signals from the dendrites arrive at the axon hillock, is of some interest here, because it is at this point that the neuron either fires or does not fire. When the brain is considered in a reductionist sense as a collection of several billion neurons, the salient problem is whether or not the neurons are firing. Physiological psychologists address themselves, amongst other things, to the question of why neurons may or may not fire, as a correlate of certain psychological states. Apart from a weak signal, other possibilities are also of interest to the physiological psychologist. Problems in the neural transmission chain that hinder the signal getting through, or help to produce a signal when firing is inappropriate, have been linked with psychological problems. For example, organic or biogenic depression has been linked to lowered levels of Norepinephrine (NE) activity in the "sympathetic" regions of the brain. A freely functioning sympathetic system presumably works against an opposing force within the brain, with the result being a neutral behavioural disposition. The brain tends to work in opposites (Carlson,1981), with a "normal" state being a neutral (or near neutral, to facilitate change) result of opposing forces. NE is suspected to be a transmitter substance in the synapses (Levinthal, 1979), so if the levels of NE are depleted, there is a lower likelihood that the receptors on the dendrites will receive the transmitter.

Whether by deduction or by accident, it was discovered that certain types of drugs relieved the symptoms of organic depression (Levinthal,1979). Mono-amine oxidase (MAO) inhibitors apparently "block" the action of MAO. MAO serves to break down the biogenic amines norepinephrine, dop-

amine and serotonin. The application of drugs that are thought to block the action of MAO results in relief of depressive symptoms. Relating depressive systems to the relative absence of brain NE, and mania to a surfeit of brain NE is the focus of the Shildkraut-Kety hypothesis (Levinthal, 1979). Tricyclic antidepressants also raise the level of brain NE by slowing down the re-uptake of neurotransmitter into the terminal button after transmission, thus allowing more NE across the synapse.

There are many other things that can go wrong in the synapse area. Examples are: 1) Manufacture of neurotransmitter may be inhibited; 2) The release of neurotransmitter into the synaptic cleft may be inhibited; 3) The re-uptake process may be too fast or inhibited; or 4) The receptors in the dendrites may be blocked or triggered by an unwanted substance.

Many research problems centre on the biochemical activities in and around the synapse. However, in spite of the microscopic intricacies of the synaptic chain, the neuron still either fires or does not fire, according to the intensity of signals received at the axon hillock: "... it is clear that at any instant in time, neurons "fire" or they don't fire - that is all they do. Nonetheless, as a result of this deceptively simple activity, all the functions of the nervous system are eventually carried out - from the simplest reflex action to the most complex act of creative thought. The idea of how such complexity can derive from such utter simplicity is one of the marvels of the nervous system "(Levinthal 1979, p13). How could such faith in reductive strategy be maintained given the relatively crude investigative methods available? An answer to this question could lie in the indeterminacy located in the synaptic clefts. As mentioned before, psychological problems can generate research questions that concern the success or failure of synaptic transmission according to what happens in the synaptic clefts, with the result that a part of the brain labeled with a certain function does not work properly. These research questions centering on the synaptic clefts can be considered in two ways:

Firstly, these problems can be construed in a negative light in that they frustrate the researcher, and are implicated in the suffering of the host person/organism. Science is seen from this perspective as being "held back" by the limits of knowledge, although the researcher may see such problems as exciting challenges.

The second interpretation of synaptic indeterminacies is one that may throw some light on the faith in reductive theory and method shown in the Levinthal quotation above. These indeterminacies may actually allow the researcher to keep a faith in the ultimate aim of complete reduction. The lack of solid answers leaves the researcher with a technique or strategy that is not disconfirmed. Given that answers about the minute entities are somewhat elusive, the scientist is able to envisage perfect or near-perfect neurophysiological reduction as being merely a long-term product of advancing

technology.

The example of depression portrayed as an organic illness is not, of course, representative of depressive illness as a whole. The broad distinction between reactive and organic depression recognises two of the possible "sources" of depressive behaviour. In addition, higher level processes are hard to ignore: "The difficulty with using reactive depression as an example of the logic of reduction is simply that reactive depression is an extremely complicated psychological phenomenon. Many of its psychological aspects are not understood. Depression involves attitudes, beliefs, desires, values and moods, and those phenomena in turn involve very sophisticated human linguistic and cognitive capacities "(Clark 1980,p37).

Apart from introducing the argument that a multitude of factors are involved with depression, this view suggests that some psychological problems are more appropriate than others for reductive analysis. Unipolar or exogenous depression may be more amenable to within-level analysis, giving rise in the clinical literature to within-level treatments such as shown in Lewinsohn & Hoberman's (1982) summary of behavioural and cognitive treatments of unipolar depression. The logic of reduction as mentioned by Clark is a complicated issue, and such epistemological matters will be discussed in Chapter Five.

The emphasis in this chapter is on the reduction from psychological concepts to singular neurons. Neurons are not expected here to carry the burden of psychological meaning in reductive analysis, in spite of the deterministic hope expressed in the Levinthal (1979) quotation. Although the neuron has been heavily implicated in the psychological field, the attribution of a concept such as purposiveness to a single neuron in an identity relationship will be critically discussed in Chapter Five, as will the factual deficits of the all-or-none version of the action of the neuron.

Also, there can be reactive problems when making a micro-level analysis of neural states. The apparatus required to measure firing of a given neuron may be responsible for changing the nature of the phenomenon under study. This problem worsens as the unit of analysis becomes smaller and progressively more basic in terms of a hierarchy of sciences This is not the only reactive problem, however. There is also the irony of the psychological beast studying the psychological beast. Harth (1982) explains: "The physiologists's task here is a peculiar one. He intercepts a message somewhere in the neocortex and - by looking at oscilloscopes or reading graphs or listening to tapes - presents this message to the very periphery of his own nervous system. But the code is inappropriate for that stage, and the message makes no sense" (Harth,1982 p74). This reactive problem is not peculiar to psychology, as with most sciences, the scientist constitutes,in type, at least part of the subject matter. Although reductive logic may recommend a reductive leap in order to escape the problem of the psychological beast studying the psycho-

logical beast, it is contended here that this is not sufficient to escape this reflexive problem.

It may be more useful to consider *clusters* or groups of neurons as the effective vehicles of psychological content in the reductionist programme. The gross properties of clusters of neurons may be more suitable as a focus for reductive analysis. If the analysis goes beyond the action potentials of individual neurons, then the aggregate properties of clusters or constellations lend themselves more easily to reductive links between psychology and neurophysiology (Harth 1982). Gross measures can be made by non-intrusive methods that measure, for example, blood flow in various parts of the brain. This can be done by injecting a radioactive substance into the bloodstream and observing with scanning equipment the changes in blood flow that correlate with a given behaviour.

Non-intrusive research methods that measure global processes from the outside can, to a certain extent, avoid the problem of the investigation changing the nature of the phenomenon in question. In atomistic fields the unit of analysis becomes small enough for the tools used to measure the unit, in this case the neuron, to interfere with the process of synaptic transmission. A global approach that monitors a large group of neurons has less chance of interfering with the action of any given neuron, with the compromise being that the correlations between the psychological activity and the neural activity become more tenuous. However, as mentioned earlier, large clusters of neurons may represent psychological phenomena better than single neurons. Legitimate atomistic science attempts to turn correlative relationships as nearly as possible into "causal" relationships, and attempts to provide an explanation in terms of more basic phenomena, knowledge of which is seen to be provided by lower-level sciences.

Taking a global physiological approach initially appears to avoid the reactive implications of intruding into the skull, because the micro-level processes are seen to be relatively undisturbed. Gross measures provide a less extreme form of reductionism by allowing the aggregate properties of large numbers of neurons (this can be in the millions) to emerge. The following section will consider methodological reductionism at a gross level of analysis, at the level of localisation of function. However the reactive problems outlined earlier are still highly likely to be present - it is more likely to be a problem of minimising the effect of :1) the observer on the subject matter; and 2) the observer being an example of the subject matter.

Research Problems in Neurophysiology.

Localisation of function.

Localisation of function in mammalian brains is a feature of neural systems that makes it possible to assign bodily and be-

havioural functions to various parts of the brain. A given part of the brain (for example, the hypothalamus) may contain or involve several million neurons. Thus we have moved away from the atomistic neuronal analysis, and consider the aggregate properties of the neurons. A high degree of differentiation is evident from one end of the brain to the other. For most bodily functions, there is a part of the brain that allows a neurophysiologist to assert some sort correspondence between the activity in that part of the brain, and the topography of the bodily function. The older, more basic parts of the brain are at the rear, near the base of the brain. Vital bodily functions are implicated in the function of this, the most primitive but best protected part of the brain. As we go forward from the base of the brain, the structures become increasingly newer and less central to the basic survival of the mammal. More peripheral functions are represented in intermediate areas, such as speech and voluntary motor activities. Towards the front of the brain are the most recent structures and these more cerebral areas are implicated with such functions as highly developed intellectual powers in humans. The highly developed cerebral cortex in humans accompanies a large degree of behavioural flexibility and an internalization of the many subtle rules and conditions that are required for successful operation in a complicated society. The continuity of cerebral advancement that appears as a function of increasingly higher levels of the phylogenetic continuum is well documented. Even without an intrusive scientific methodology, it can be seen that animals with more advanced (not necessarily bigger) brain structures can do more and have a greater degree of behavioural flexibility than those lower on the phylogenetic continuum.

The ability to localise the area of the brain concerned with a given behaviour has important implications for a reductionist scientific approach, especially regarding methodological matters. The ability to localize brain functions vindicates, to a certain extent, a methodology that investigates biological phenomena in the name of psychology. A typical example would be, for instance, electrical stimulation of the lateral hypothalamus of the rat (Carlson, 1981). When stimulated in this way it eats continuously and gets fat. This provides some evidence to suggest that the lateral hypothalamic area is involved with eating. Since intrusive electrical stimulation is thought to simulate the natural activation of brain centres, the lateral hypothalamic area is hypothesised to be some sort of locus of eating initiation. This is a somewhat oversimplified account of a complicated biological and psychological phenomenon, but the intention here is not to provide an account of the ontological intricacies of a given example, but to illustrate the methodological manifestation of a reductive principle.

The reductive principle that is being illustrated by the lateral hypothalamus example is that if one proceeds to investigate

the neural processes underlying a given behaviour, then one has a more basic and more real account of the phenomena under study. This sort of reasoning stems from the days when lower level sciences such as physics had a monopoly on reality.

There are of course translation problems between the two sciences, such as were pointed out by Jessor (1958) and these will be discussed in Chapter Five. The localisation of function enables a deterministic inference to be made between the processes at two different levels. If function were not localised for bodily function, behaviour and subjective states, then reduction to physiology would be a somewhat more difficult task.

The strict one-to-one relationship that localisation of function allows may have come under some threat from relatively recent empirical developments in neurophysiology. Extensive loss of nervous tissue from accidents or lesions has often been followed by a large degree of recovery or restitution in certain circumstances (Laurence & Stein, 1978). To keep to the strict determinism that says certain brain structures have certain functions may involve ignoring the evidence on recovery of function such as that presented by Laurence & Stein (1978). The ability of parts of the brain surrounding damaged areas to "take over" the function of the damaged area shows some variability in what was previously thought to be a fixed relationship.

The recovery of behavioural function is not necessarily interpreted by Laurence & Stein (1978) as "plasticity" (which can refer to global changes in neural organisation as a result of damage, including the "taking over" of brain function by nearby areas) or reorganisation, especially if the brain-damaged organism is able to compensate behaviourally. However, restoration of brain function is inferred when some degree of behavioural function is restored without "masking" by similar behaviours or novel tactics. Plasticity is considered by Laurence and Stein as a process of recovery of function. Alternative structural explanations listed by Laurence and Stein include redundancy, which is the possibility that sufficient specific tissue remains to do the job, and multiple control, which localises a given function in several places.

Process approaches to recovery of function (mechanisms which occur after the damage) are of greatest interest here, and include functional substitution (similar to multiple control), which refers to the taking over of the functions of the damaged areas by another, and plasticity, as defined above.

Plasticity is a feature found not only in brains that have been damaged, but also in normal, growing brains: "Shifts in function of CNS structures need not occur only in response to brain injury, but may also be the natural consequence of development processes that continue throughout life" (Goldman 1974; in Laurence & Stein 1978). This version of plasticity is the moderate version. A weaker version of plasticity refers to such anatomical changes as "axonal sprouting", and "regeneration", and a stronger version refers to a continual transformation in

global and specialized operations (Laurence & Stein 1978) that precludes the localisation of function entirely. If we stay with the moderate version for the time being, a pertinent question to address is: given that a shift in CNS function can occur as a process of recovery as well as normal development, can we keep a formal mapping relationship between psychology and physiology?

This depends on the degree of precision that is demanded of the relationship between psychology and physiology (Clarke, 1980). If brain function is only loosely localized then it is possible to keep a reductive strategy if the conditions regarding successful reduction are not so strict as to demand, for example, that a particular neural mechanism be found for a given psychological phenomenon. Another condition on successful reduction could involve the time factor, and would demand that particular identities obtain at every moment (Clarke, 1980) . As Clarke points out, this would be a very difficult condition to fulfil. To regard this condition as necessary for successful reduction, one would have to conduct one's research with a faith in technology equal to that of Levinthal (1979), or admit methodological failure.

Taking Laurence and Stein's (1978) extreme version of the concept of plasticity, which says that the brain undergoes continual transformations that preclude the assignment of functions to neural localities, it would be appropriate to analyse the implications of this in terms of the degree of precision that is required of a reductive strategy. If localisation of function is an impossible objective in such a chaotic system, then one-to-one mappings of a strictly deterministic nature are of course completely ruled out. Can successful reductionism still be said to be achieved even though the method fails to reveal even the most vague of mapping relationships? This would force the loose localisation laws outlined earlier to be stretched to the point of absurdity, saying that there is a neurophysiological basis to behaviour but it cannot be pinned down. Thus methodological efforts to localize function in this extreme case fail, although the endeavour can still be considered reductionist because the explanatory investigation is still conducted at a "lower level" than that of the phenomenon to be explained.

The System in Neural States

Let us suppose that a one-to-one mapping relationship between a given psychological state and a specific neural state is difficult to infer. However, a many-to-one relationship looks increasingly likely, and the structural concepts of multiple control or neurophysiological redundancy provide models that account for a set of hypothetical data. The concept of the system emerges as limitations in the one-to-one model become too obvious to ignore .

Complicated feedback systems gradually take over the explanatory role that one-to-one mappings previously provided. Carlson (1981) states: "The term 'feedback' should be

self-explanatory: it refers to the consequences of an action affecting the factors that initiate the action"p363. An internal feedback system, such as that of thirst regulation, involves processes and cues from such diverse areas as neural centres, internal and external perceptual equipment, blood-borne cues etc. Carlson (1981) describes living beings as open systems, exchanging energy and matter with their environments. A system such as O'Kelly's (1963) model of regulation portrays the internal environment of the biological unit as interacting with the physical world surrounding it (figure three).

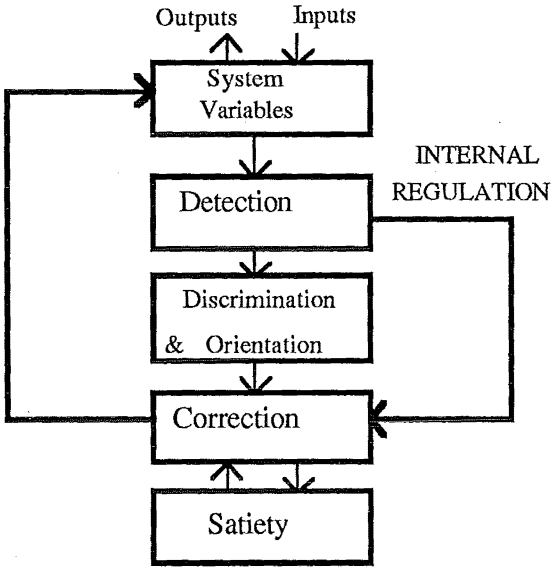

Figure three. O'Kelly's model of regulation. In Carlson (1981,p363).

This model can apply to thirst and other homeostatically controlled/triggered physiological mechanisms. As systems begin to emerge in explanatory discourse regarding physiological variables, precise localisation of function becomes a less feasible objective. The implications of a system-based view of physiological processes for reductive determinacy are, however, not as extreme as those of Laurence & Stein's (1978) third definition of plasticity (continual transformation precluding localisation of function). The ontological status of an internal system does not appear to preclude localisation of function according to the Clarke (1980) loose criteria which allow for some indeterminacy without precluding successful reduction. Systems within an individual, as the unit of study, can still be thought of or examined in reductionist terms, but have implications of scale that may render reductionist strategy increasingly redundant. The physiological system such as that which regulates thirst and drinking is considered "open" in that the sun, for example, may dehydrate the individual. This analysis of the individual interacting with the wider environment pays some recognition to the concept of an individual being part of a larger system. However, this systemic approach in physiology such as is represented by the O'Kelly model at best implies only that the individual is part of a wider physical system. At worst it merely states the obvious point that the physical system interacts with its environment. Thus thirst considered as a behavioural phenomenon is still reduced to a physical phenomenon, with the role of the physical environment being recognised.

This raises the question: Is thirst a psychological or physiological phenomenon?

This would depend on the existence or extent of psychological content in the investigative theory or method used. One could class the inputs as including psychological concepts, e.g. "seeing someone drink". This brings the onus upon the physiologist to say when and how the psychological concepts become physiological (given that the reductive game is indispensable). The perceptual apparatus may be cited as the interface between psychology and physiology. If one is to differentiate between psychological and physiological terms, then this problem of where and how the psychological phenomena become physiological phenomena remains an ontological obstacle to good explanation. Chapter Five will consider the epistemological problems of translation of terms between sciences.

Summary.

It appears that although an internal systems analysis provides a better picture than localisation of function, postulating the existence of an internal system still does not take into account the role of the physical or psychological environment. Considering physiological mechanisms as open feedback systems is an improvement but can still allow exclusive reference to the physical environment, ignoring possible psychological explanations. When psychological concepts are introduced, they are underdetermined by physiology. Thus the open system concept lies open to some improvement, which will be attempted in Chapter Four.

A Problem of Causal Inference in Physiological Psychology.

Part of the methodological approach in physiological psychology involves taking a psychological problem and citing some lower order variables that are thought to be involved with the psychological phenomenon. When isolating physiological variables, it is usual to examine for or hypothesise about the physiological states that immediately precede the psychological phenomena. As will be seen in the chapter on explanation, this unitary step backwards in the causal chain apparently constitutes adequate investigation for some problems. The physiological variable that is isolated is seen as the cause of the psychological phenomena.

To resurrect the depression example, the faults in the synaptic clefts that are hypothesised to cause the depletion of neurotransmitter in the sympathetic system of the brain can, at least in the case of endogenous, biogenic depression, be thought of as "hard-wired". Reductionist efforts at changing the behaviour/cognitions are directed towards the "hardwired" problems that accompany the behavioural deficits, namely changing the physiological state.

The problem of causal inference that arises in a case such as in a reductive analysis of depression is that it is difficult to infer that the biological problem caused the

psychological deficits, given the possibility that the biological problem could have been "caused" by the depressive behaviour. If a long period of, for instance, exogenous depressive behaviour could indeed "hardwire" the physiological symptom into the neural states, then a problem of causal inference of the "chicken & egg" variety is apparent. If it is accepted that in a given case, inferences about a neural deficit enables reliable predictions to be made about the behavioural state, then the possibility remains that the physiological deficit could have been set up much earlier in life, either by "learning" or by some physical effect of the environment. Since causal chains will be discussed in Chapter Three, it will suffice here to say that such causal uncertainties may be a result of the type of reductive method used, although this is not to say that any alternative methods are necessarily crystal-clear regarding causal inference.

CHAPTER THREE

Explanation, Causation and Reductionism

This chapter deals mainly with explanation, causation, and description in psychology, in preparation for Chapter Four which will examine the capacity for reductive analysis to provide an account of each of these. Firstly it is appropriate to attempt to say what it means to have an explanation in psychology. One possible answer to this is that explanation is an attempt to render something intelligible (Valentine, 1982). The Collins English Dictionary (Hanks, 1985) defines "explanation" as "to make (something) comprehensible, especially by giving a clear and detailed account of the relevant structure, operation, surrounding circumstances etc". Without entering the circularity that the dictionary definition entails, the first problem we strike when we attempt to define explanation, is that we must employ some sort of explanation to define it. On the face of it, a reference to intelligibility or comprehensibility appears to ground the term "explanation" in something external, but we may not be able to step outside an explanatory mode in order to avoid a non-circular definition. However in order to provide a coherent account of explanation this reflexive problem will be ignored.

The second problem with the definition - "renders something comprehensible or intelligible" - is that it is nowhere near specific enough. If psychology is regarded as an empirical as well as a theoretical exercise, then the question of what renders a problem or question "intelligible" must be answered in terms that are at least more specific than the question. Specificity can appear, for example, in the operational terms that are generated from an explanatory theory. The following section will briefly outline some types of explanation occurring in psychology, leading into a discussion of theories of knowledge and their relation to the entities that require explaining.

Explanations in psychology and science can often, but not necessarily, refer to something that happened in the past. The state or phenomenon or process to be explained is considered as a temporal unit of analysis, fixed in time or bounded by an interval. This unit is taken in abstraction from the continuity of events that presumably exists independently of analytic observation. The given temporal unit may then be explained in terms of the events and processes that

preceded it. The scientific study of the ontological world proceeds following the assumption that certain states follow certain other states in a deterministic fashion. If event A is considered as being caused, it need not necessarily follow that event A must be found to be *sufficiently* caused (Katz, 1983), allowing for some indeterminacy to emerge from scientific investigation.

Explanation in psychology is not necessarily restricted to causality. Teleological explanations, which explain phenomena in terms of purpose, or functional explanations, which focus on associations between events, are not intended to be evaluated from a causal perspective (Valentine, 1982). Valentine makes the point that there is no point in evaluating one type of explanation from the viewpoint of another. This relates to a point Garfinkel (1981) makes in consideration of Kuhnian paradigmatic factors in explanation. Shifts in the explanatory framework occur over time, in response to the old framework becoming increasingly unable to account for observed phenomena. Technological advances, (mentioned in Chapter Two) are seen here as being contributory to reductionism *as a problem* by providing the incremental knowledge that maintains the reductionist's faith in the reductive process, may provide the observations which stretch the "old" framework to the limit. Garfinkel refers to the shifting of the conceptual frameworks not as a change in the answers given, but as a change in the sorts of questions asked. For example, in physics, the reply to the question "why do objects keep moving?" became "they just keep moving". This problem concerned the theoretical shift from medieval to Newtonian physics (Garfinkel, 1981). Newton offered a new question, that of why the motion of an object changes. When the best available answer seems somewhat vacuous with regard to the question, then the limit of the explanatory framework has been reached: "Attending to the questions rather than the answers and looking for the implicit question hiding behind the answer are a useful device for analysing explanations and understanding historical shifts. In general, epochs in history, the history of science or any other history, are marked by the questions they asked as by the answers they give." Garfinkel, (1981),p8.

The Garfinkel (1981) quotation has served to introduce the idea that conceptual frameworks are subject to periodic change. A relatively recent conceptual shift in physics concerns the field of quantum physics, where the question "what is the nature of matter?" changed to "does matter exist?" Koestler, (1959). Explanation can even involve two different conceptual frameworks operating on the same data, when for example, an electron is considered sometimes as a wave and other times as a particle (March,1978), or when in cognitive psychology, "associative network theory" and "semantic feature theory" account for the same set of data (Wickelgren,1981). When observational data can support more than one theory, the criteria for sufficient investigation are usually insufficient for

adequate determination of the theory or model being used. Technological advances are seen here from a post-Kuhnian perspective as helping to precipitate a conceptual shift, but not being enough in themselves to account for paradigmatic shifts. It may not be changes in technological knowledge that change a conceptual framework, as much as the less quantifiable conceptual shifts that result from such advances.

Explanation Through Theory.

Three terms above have been used virtually interchangeably, namely "theory", "paradigm" and "conceptual framework". Although the terms "paradigm" and "conceptual framework" are used here to say the same thing, the term "theory" is somewhat more specific, and refers to low-level propositions that can be abstracted from data. These propositions (Valentine, 1982) can consist of symbolic representations of: 1) observed relationships among measured events; 2) the mechanisms or structures presumed to underlie such relationships; or 3) inferred relationships and underlying mechanisms. Theories can be ideas about the world, and they differ from data by one level of abstraction. Data too can be seen as theoretical, in that certain "pretheoretical" and theoretical assumptions are manifest in the way data are collected. For example, the decision to investigate the role of the hypothalamus in enraged behaviour follows from an assumption that neural investigation provides a more basic account of the phenomena than a within-level analysis. However, even before the method of investigation is chosen, there are assumptions present that represent theoretical viewpoints, for example that experimental data provide a type of knowledge that is superior to experiential data. Fell (1977) called phenomenal experience "pre-theoretical" in that experiential considerations are brought to the experimental context. However, Fell's "pretheoretical" concepts will be treated here as "theoretical", due to an assumed theoretical (not necessarily scientised) nature of experience.

Seeing experience as pre-theoretical accords ontological (factual) status to experience above that of the theoretical. This traditional view treats data as providing a "special window" to the world. Although both theory and experience are seen to have similar theoretical status, it is postulated that data and the resulting theory can in some cases have lower "ontological validity" (in other words, is a less adequate theory of facts) than experience due to a degree of abstraction from the ontological world resulting from badly operationalised constructs (poor measurement). For example, if complex cognitive and emotional processes are measured by bipolar responses on a paper questionnaire, then the subsequent theory is based on data obtained at a more abstract level, leaving the theory somewhat underdetermined by the supporting data. In a case such as this, the data and the subsequent theory can have somewhat lower

"ontological validity" than experiential data.

The preceding discussion serves to introduce the concept that explanation in psychology is attempted largely through theory, whether explicit or implicit. Theories can carry the burden of explanation, consequently the strengths and weaknesses of a given theory, to some extent represent the adequacy of the explanation. A working assumption in this thesis is that explanation is a reasonable objective in psychological endeavour. Practical considerations such as problem solving or accountability to outside interests are seen as "flowing on" from good explanation.

There are several different types of explanation available in psychology (Valentine, 1982), including causal, functional, teleological, structural, generalisatory and hermeneutic. The first four will be considered here with the greatest emphasis being placed on the contrast between firstly, causal accounts and secondly, structural and functional accounts.

Causal Explanation

A good causal account has an historical aspect to it that the structural account does not have (Valentine, 1982). and recognises cause-effect relationships over time. Causal relationships can be described in a number of different ways, and three outlooks that provide differing views of causal explanation are the realist, Humean and deductive-nomological views. The latter two views will be merged later in the chapter into one "standard view of science", after Manicas and Secord (1983). The Humean concept of causality follows a "billiard ball" model, where a sufficient cause is based on a measurable cause having a measurable effect. Valentine (1982) cited two essential ingredients to be conditionality and relevance: "Thus, the occurrence of an event B is explained as being the result of an antecedent A having occurred , A being a condition for B"p100.

Such a causal account allows for some indeterminacy to occur between cause and effect as the time gap between sufficient cause and effect increases. The closer the temporal relationship between cause and effect, the more confident one can be about making determinative statements regarding the relation of the hypothesised cause to the effect.

In psychology, cause and effect are usually mediated in some way by the biological organism. Frequently the inputs and the outputs are measured. In a causal account of behaviour, this may be all that is required for sufficient explanation. In a structural account, the topography of the outputs may take second place to inferences regarding the structure or function of something that lies within the boundaries of the biological organism. The structural account treats the internal workings of an organism as an interesting object of study in itself.

The Humean concept of causality as in-

terpreted in psychological work relates cause and effect through an organism, but not necessarily explicating the internal workings of the organism. The behavioural tradition in psychology has stressed the probabilistic relationship between stimulus and response, and has applied "laws" of learning to demonstrate the important role of the immediate environment in the determination of behaviour. Behaviourists also stress the importance of conditioning histories. This probabilistic, retrospective relationship was taken to a philosophical extreme in Skinner's radical behaviourism, which sought to eliminate the role of the biological organism in the prediction and control of behaviour. Skinner himself saw radical behaviourism as a philosophy (Skinner, 1974), although the impact of behavioural science on psychology has probably been more pragmatic than philosophical. However, it is not the purpose of this chapter to give an account of behaviourism. Skinner rejected the concept of explanation as a suitable goal for psychology (explanation misleading the scientist into wasting time on "explanatory fictions") preferring prediction and control as more suitable objectives. The purpose of mentioning behaviourism then, in a chapter on explanation, is to outline the influence of behavioural psychology on a discipline that takes explanatory tasks seriously. This influence leads to making theoretical concepts more accountable to the ontological world through the process of measurement - an astute analysis of behaviour enables the theoretical constructs or models to be well represented in data. The Skinnerian legacy helps us to avoid, for example, the indeterminate excesses of the Freudian psychodynamic system, and helps "close the gap" between stimulus and response to facilitate more accuracy in the theoretical excursions of psychologists.

The second view of causal explanation to be mentioned here is the "realist" view, although this will not be explicated in great detail. The realist outlook as described by Manicas and Secord (1983) incorporates the view (very briefly) that data do not provide "givens" on which the test of truth is correspondence, and epistemologically, there can be nothing "known" with which theories and constructs can be compared. In spite of this, according to Manicas and Secord, "... it is precisely the task of science to invent theories that aim to represent the world"(p401). Realist philosophy of science assumes that there is a "real world" that exists independently of the conscious efforts of scientists and other people.

Since all knowledge in a realist philosophy is "theoretical", the elevated ontological status that traditional science accords data is seen as invalid, reinforcing a point made earlier in the chapter that muddies the distinction between experience and data. The direction of this is important, however: data are reduced to experience; experience is not reduced to data. The realist takes it that there are real things about which to theorise, and looks at the world through theory (the only possible way),

wherein lies a problem: if theory is the only way we can look at the world, then what basis is there for a believing that there is a real world apart from the fact that we have theory? One can, however, see the pragmatic value in the belief, since it gives the researcher something to work for. Leary (1984) questioned the status of a realist ontology given the fallibilist epistemology of the realist: "Exactly how Manicas and Secord propose to link experience - which they propose to be culturally mediated - with reality independent from experience is an issue I shall leave for them to clarify"(p918). It appears that one must take on the realist belief in a real world in order to see theory as the real world's representative.

However if we accept at least that knowledge operates in an inescapable theoretical mode, the realist programme allows for the use of theoretical constructs that the Humean programme cannot cope with. In striving to explain problems in psychology, the realist research paradigm enables the psychologist to infer internal states that at least help to put together an adequate explanation of behaviour.

The deductive-nomothetic view of science as described by Manicas and Secord (1984) "presupposes that the world is a determined concatenation of contingent events", and allows theory to yield data that have an ontological claim on reality but contrasts with the new realism in that the deductive-nomothetic view of science attempts to provide "givens", from which science can progress.

Pragmatic Explanations

A type of explanation that is worth mentioning but will not be detailed at length is the pragmatic explanation, which gives the phenomenon in question an explanation which is suitable according to the situation-specific conditions at the time. Such pragmatism may of course be better thought of as a criterion for assessing the adequacy of an explanation. An example of a pragmatic explanation in psychology could be when the elucidation of a physiological process enables a person to make adaptive attributions regarding the reasons for certain behaviours. For example, the explanation to a highly stressed person who drinks ten cups of coffee a day, that this consumption raises the level of central nervous system stimulant to such a level that normal functioning is impaired, is likely to prevent that person from generalising the source of the stress to inappropriate areas, or the explanation may simply ground the source of the arousal in something physical, making the person feel better. A pragmatic explanation could be loosely defined as anything that "works". The pragmatic criterion may well be one of the strongest sources of support for reductionist arguments, as the field of psychology can often be complemented by a knowledge of physiological underpinnings. However, pragmatism is not the only criterion worth considering when assessing explanation in academic activity, and problems can arise when the reductive explanation is seen *in itself* as good explanation or

good psychology. Other criteria for assessing an explanation in psychology as a science can include parsimony, extent to which new information can be supplied, internal consistency, or degree of reference to the ontological world.

Causation and Description

Causal accounts as explanatory vehicles can be seen to lie on a continuum between the Humean regular conjunctions, and the realist theorising about hidden generative mechanisms. Although causal accounts can vary in the extent to which they are based on an attempt to generate hidden mechanisms as mediators of the inputs and outputs of the biological unit, they are generally similar in that they provide an historical dimension to the explanatory picture. Explanations that posit the structure or process of internal workings can be relatively devoid of historical content, whilst the probabilistic relationships observed in a behavioural research mode may provide more historical content with an emphasis on dispositions to respond based on learning histories. The Humean concept of causality when applied as a set of probabilistic relationships between antecedents and consequences results in a retrospective science which makes predictions on an inductive basis.

The concept of cause as providing an explanation is useful in that a relation of cause to effect helps to render the problem more comprehensible or intelligible, although a full set of causes may not be necessary in cases where pointing only to those changes which "tip the balance" appears sufficient (Manicas & Secord, 1984). This view of causation sees "causes" as being restricted to the precipitant factors involved in a determinative chain. The relates to the notion of "partial causation" which will be outlined later in the chapter. However, when precipitate causes such as "the marriage broke up because the car broke down" become insufficient for good explanation, it then becomes appropriate to go back further in the causal chain.

The reductive explanation in psychology yields information that infers effects emanating from within the organism. This carries implications of blame (touched on in Chapter Four in a discussion of individualism), although the deterministic links sought in the scientific world, would in theory contribute to an absolving of blame in individuals. The observer looks "downwards" for causes that are seen to act in an "upward" direction. Garfinkel's (1981) notion of partial causation is relevant here, a concept that relegates the popular scientific notion of "cause" to being better described as a precipitant. The common conception of a causal chain is reinterpreted as a chain of precipitation. Garfinkel claims that the term "cause" is often restricted to those factors which it is possible to control - thus a pragmatic element shapes the definition of a cause. Given these reservations, figure four illustrates the multiple directions of causal

influence between physiology, psychology and the environment in an effort to demonstrate the simplicity of the reductive route in psychology, which reduces behaviour to physiology.

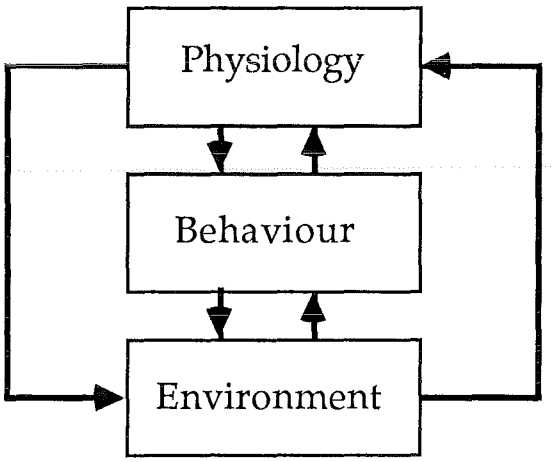

Figure four. Diagram showing directions of possible causal influence in psychological research.

The complexity of figure four serves to illustrate the convenience of choosing a simple cause-effect reductive link. By limiting the investigative scope to one regressive step, the problem may appear to lend itself to a reductive strategy in the deductive-nomothetic mode. Causes in the deductive-nomothetic view are seen as a long chain of small cause-effect relationships, and questions relating to this, such as the time gap between cause and effect, or what constitutes a temporal unit of analysis, or even what is a moment in time, are interesting but beyond the scope of this thesis.

If the behaviour of people or organisms is seen as being caused in a long, deterministic chain of cause and effect, then we have a state of infinite regress (Valentine, 1982). As the causal chain is taken further back in time, each step may become increasingly less causal and more *descriptive* as the determinants become more remote. This may effectively render the search for causation a purely descriptive exercise.

Going back to Manicas and Secord (1983), they interpret the "standard view of science" as explaining phenomena through laws. They describe a full or complete explanation as deductive-nomothetic (generating laws from which predictions about the world can be made), although in research practice, Manicas and Secord say that explanations are inductive-statistical. The laws in the deductive-nomothetic mode are generated from the observation of *contingent* events, these events being related to each other in a probabilistic fashion. From the contingencies already observed, inductive reasoning leads to the postulation of laws which enable deductions to be made about the *future.*

This standard view of science, as mentioned earlier, is epitomised in Skinner's radical behaviourism. How does a reductive approach fit in with Manicas and Secord's standard view of science? Initially, a reduction from psychology to physiology (for example explicating neural structures involved in depression) appears to have something of a realist orientation, although realism does not require one to be a reductionist. However, it must be remem-

bered that the limits of determination permitted by physical measurement techniques in neurophysiology allow, at best, a close *correlation* between psychology and physiology to be postulated. The correlation between psychology and physiology enables retroductive inferences to be made that say that a certain internal state "controls" a certain behaviour. The relationship between the two levels of phenomena is still a contingent relationship between events, and not necessarily a "contingent concatenation of real structures". Therefore, reductive psychology appears to fit in with Manicas and Secord's standard view of science that extends inductive-statistical relationships into deductive laws.

To conclude, the problem that remains is that whilst a reductionist strategy may well produce adequate deductive-nomothetic science, it is contended here that the descriptive account of the reductive-causal research strategy may still be inadequate for good explanation, due to the lack of scope in the *description* that reductive science provides. Thus a reductive explanation provides a descriptive account of the states or processes of limited scope at a lower level of science. These reductive explanations are based on the idea that theory A is reducible to theory B if B explains all the observation sentences from theory A. The descriptive or explanatory power of reductive psychology will be critically discussed in the next two chapters. Chapter Four will continue the theme of explanation in psychology, and will relate explanations to the various levels of science from which an explanation can be obtained.

CHAPTER FOUR

Levels of Sciences

A Hierarchy of Sciences

Before the epistemological or linguistic treatment of the discussion of translation problems between different theoretical levels in the next chapter, it is appropriate to describe the concept of levels of scientific theory in some detail. An ordered hierarchy of sciences is a key proposition behind the doctrine of reductionism (Jessor, 1958; Rose, 1985; Hodgson; 1985).

This sort of conceptual scheme predisposes or at least goes along with a methodological assumption that certain methods of enquiry yield some sort of more basic information than within-level explanations. The postulation of a hierarchy implies that the lower levels have some sort of factual (ontological) priority over the higher levels (Rose,1982), although this priority is not endorsed here. This information has a greater generality or applicability due to being at a level that is distributed more widely. For example, genetic material is essential for determining many characteristics of human biology and to a certain extent, behaviour, but is also found in all forms of life on earth.Thus a reductive approach in psychology may investigate the genetic basis of a particular pathological state, but the genetic material yields information of far wider applicability.

The levels of sciences here are considered as conceptual levels, although in scientific work they are also taken to represent levels of systems or processes. Consequently the method of enquiry that follows from the conceptual hierarchy through a faith in levels of systems, is a method whereby the activities and structures of the lower-level system are measured and manipulated. The application in psychology of this method was the subject of Chapter Two, where the nature of the neurophysiological apparatus was briefly outlined.

The sciences can be arranged in hierarchical form from the lower-order to the higher-order, in a list that usually runs from physics or sub-atomic physics to social sciences such as sociology, and includes all the disciplines between the two extremes. The actual contents of the list can vary somewhat from account to account, but a typical such list might look like figure five.

At the bottom of the hierarchy, the more fundamental components of the world are in-

vestigated. Moving upwards, a standard assumption is that sciences or disciplines of increasing complexity are revealed until the higher areas sociology and religion are encountered.

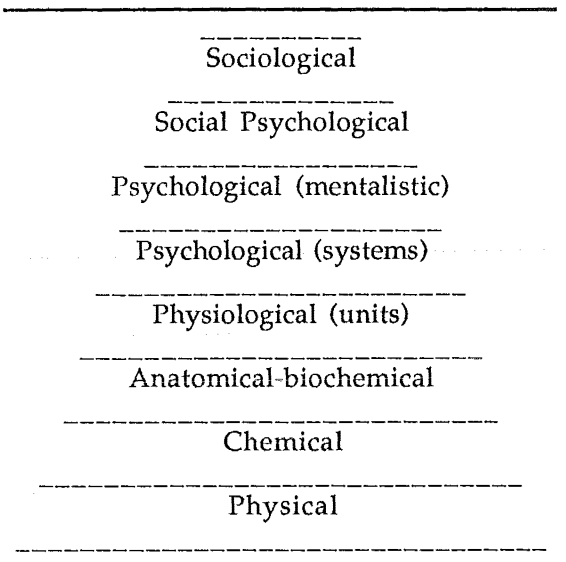

Figure five. The conventional hierarchy of sciences (from Rose,1985).

The size and scope of the unit of analysis changes by degree, and some would say by kind, in the progression from one step to the next. A reason to say that the sciences differ in their content in kind would be to preserve a role for a given science. The dilemma here is that the uniqueness of a science intuitively precludes reduction. Reduction taken to its logical extreme is an exercise in actually stripping a science of its identity by reducing its content to that of lower-level sciences. The identity of a science has a lot to do with content. For example, it is difficult to say, as with neural identity theory, that "depression is a problem of biology", since it isn't in itself. If "depression" is called "biology" then two different words for the same problem render one term redundant.

The concept of a hierarchy of sciences enables certain links to be made between the sciences, particularly the ascription of levels of sciences, and enables some disciplines to be seen as more basic through the wider generality (mentioned earlier), precision, parsimony and applicability. Rose (1985) warns that the notion of a hierarchy of sciences implies that the lower level sciences have a factual priority. It is argued here that this is not problem, and that the argument can be turned on its head to argue that the existence of higher-level disciplines implies that their *complexity* be recognised.

Two alternative ways of looking at the success of reductive methods emerge: 1) either the modern attempts at reductive problem-solving are reinforced by the practical nature of the reductive solutions (with reduction also providing an adequate explanatory framework for the time); 2) or the world may indeed be composed in an atomistic manner, with reductionist analysis providing scientists with a monopoly on reality. Although this is something of a "chicken-and-egg" problem, this writer would tend to favour the former way of looking at reduction. Of course a dedicated reductionist would say that the former assertion is successful *because* the latter assertion is true.

A hierarchy of sciences enables lower-order sciences such as physics to claim to be

part of a higher order sciences such as psychology, although the reductive leap usually only involves a jump of one level, for example psychology may be reduced to physiology, or biology may be reduced to chemistry. Also, the direction of reduction is invariably downward, to the level immediately below that at which the target phenomenon is situated. Modern or post-Newtonian science has of course scored some spectacular successes by taking a phenomenon out of its home domain and reducing to a lower level. "Reduction upwards" can occur where the explanation is taken from a level above the target level. An example from biology would be where the explanation for a problem such as coronary illness (Lagerspetz, 1984) lies in the psychological domain of stress or emotional imbalance. The notion of reduction upwards still involves a simplification by referring to a single concept at a higher level. This bears some relation to the Llewelyn & Kelly (1980) term "sociologism", where psychology is dissolved into abstract notions involving society. Llewelyn & Kelly see it as being important that some agency or individualism is retained in psychology. This has some similarity to the notion of "downward causation" where the higher-level laws determine the distribution of lower-level events and substances (Campbell, 1974), but is far less systematic. Single concepts, whether reduced upwards or downwards, will be discussed later in this chapter.

The "top-down" explanation imposes higher-level variables on the target phenomenon. This type of explanation goes some way toward integrating the target level into a system - the target phenomenon is thus seen as part of a larger whole. The top-down explanation provides a teleonomic or goal-directed explanation whilst avoiding the teleological concept of purpose (Rose, 1985). The top-down explanation is the most likely sort of explanation to stray from physiological facts.

Within-level explanations relate cause and effect without recourse to different scientific levels of theory. Thus a psychological explanation for depression may involve variables that lie in the psychological domain, such as reinforcement schedules. The within-level explanation has a certain simplicity that does not beg questions of translations between it and lower levels. There are no problems of overlap of terms and no demarcation problems with other levels, since the other levels of science are largely ignored. Also, there are no arbitrary decisions to make as to where to limit the search for the ever-decreasing units of analysis. Reductionists would worry that the within-level mode of explanation may allow the enquiry to continue in possibly unfruitful directions, untrammeled by the "harder" facts provided by the lower-level science. There is some merit in this assertion - psychological models that stray too far from the underlying physiological correlates (e.g. Freud's psychodynamic model) can lose their value as good explanations and lead to wasted research. The use of models as reductive tools will be discussed in

Chapter Five.

"Bottom-up" explanations are the domain of reductive analysis. These explanations use information from the lower-level domain to investigate the target phenomenon. Such explanations have considerable credibility in scientific circles. The wholes are broken down into parts with the parts being studied. There is some commitment to "build up" the parts again into some sort of whole, but it is contended here that this often does not occur, and is a task not taken seriously by reductionist researchers. In psychology journals, if any synthesis or building-up of the theoretical concepts is done, it is usually restricted to the more speculative parts of the discussion.

Going from the lower end of the hierarchy to the higher end, the size and scope of the unit of analysis changes. Each upward step involves a broadening of the scope of the unit of analysis.

Two diagrams illustrate the perspective from within two disciplines that lie at each end of the hierarchy - psychology and physics (figures 6a & 6b). Each diagram emphasises a different perspective according to how it would appear from within the discipline. In physics the stress is on generality, whereas in psychology the stress is on levels of complexity. The term generality refers to the fact that the reported content of physics and chemistry constitutes at least part of all the other sciences. Complexity here refers to the fact that from the perspective of a hierarchy of sciences, many sciences contribute to the make-up of a discipline such as psychology. The reductive view which sees physics as some sort of fundamental science undoubtedly stems from a time when physics had a good grasp of of reality, and had an infinite generality. The elusive indeterminacies of quantum physics, however, appear to represent an end-point to the gradual transition between sciences that encourages the notion of a hierarchy. To a certain extent, the hard realities reported by conventional physics and higher sciences are called into question by such problems as: the more that is known about the velocity of an electron, the less is known about its position (the Heisenberg principle); the mystery of the quantum leap; and even the counter-intuitive notion that the furniture we sit on is composed largely of empty space (Koestler, 1959).

In the light of these sorts of problems, the word "atomistic", used to describe the method and analysis of reductive science loses the descriptive power of referring to the smallest unit possible. Derived from the word "atom" the term "atomistic" now no longer is derived from the most fundamental unit available, unless the term is interpreted as representing a search for the smallest units at any level. In physics the problem of the ever-diminishing unit of matter has been avoided to a certain extent by conceptualising structures as energy fields (Llewelyn & Kelly, 1980).

The notion of a hierarchy of sciences is taken here to mean that lower-level sciences make up at least part of the content of higher-level sciences. Given that certain

PHYSICS

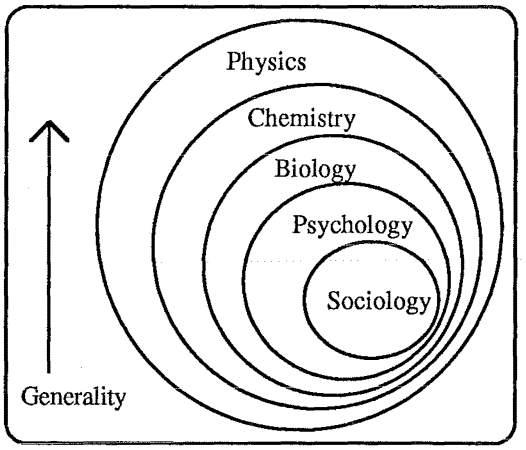

Figure 6a.

PSYCHOLOGY AND SOCIOLOGY

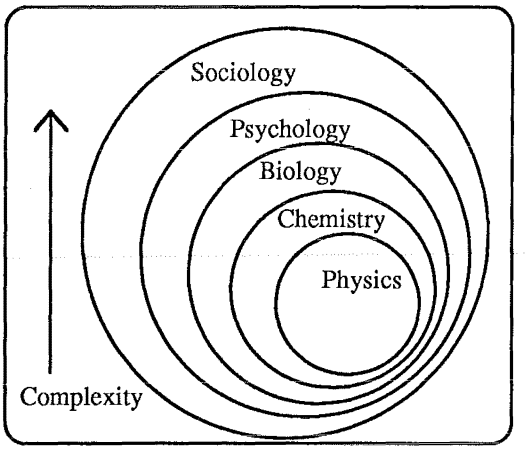

Figure 6b

Figures 6a & 6b. The differing perspectives from two different ends of the hierarchy of sciences. From within physics, generality is stressed. Fromwithin psychology and sociology, complexity is stressed (adapted from Vollmer, 1984).

indeterminacies occur at a very basic level, is it then reasonable to expect that these indeterminacies are reflected in increasingly higher levels? The very concept of a hierarchy of sciences would lead us to expect so. Recent developments in the field of "chaos" theory in physics throws some doubt on the strict determinism that is supposed to link the sciences in a hierarchy. Crutchfield, Doyne Farmer, Packard, & Shaw (1986) hold that in a simple system such as is represented by a billiard-ball model of causality, small uncertainties in the initial collisions are magnified with each collision, so that the effect becomes unpredictable in a very short time.

There is, according to Crutchfield et al (1986) an "exponential amplification of errors" that ensures that prediction in certain types of system is impossible. They present a paradox whereby uncertainties are magnified very quickly, precluding prediction, but "on the other hand, the determinism inherent in chaos implies that many random phenomena are more predictable than had been thought"(p38).

Crutchfield et al (1986) describe geometric forms that create randomness in ordered ways, however it is the amplification of uncertainties that is of interest here. The implications for reductionism of chaos theory appear to be that the uncertainties of quantum mechanics, combined with the amplification of chaotic effects as we move up the hierarchy of sciences render a deterministic reductive link between any two sciences to be on highly dubious foundations.

However, it would be somewhat premature in psychology to say that quantum physics combined with chaos explains something like human behavioural unpredictability. Human behavioural unpredictability may be more parsimoniously attributed to chaos at the behavioural level. Thus Crutchfield et al (1986) still appear to hold with the reductionist assumptions of a hierarchy of sciences.

The Unit of Analysis in Psychology

The unit of analysis in a given science is an important part of how that science gains its identity. Some independence from the units of analysis of adjoining sciences is necessary, although some overlap of research territory is to be expected. The reductive tradition in psychology has focused on what will be called the "biological unit", which refers to the being within the physical bounds of the body. Such concepts as "personal space" extend this boundary a little but not to a great extent. This section will examine the nature and place of this biological unit in psychology.

Towards the end of Chapter Two an attempt was made to show that the difference between analysing the role of a neuron and analysing the role of certain centres containing millions of neurons represented a shift in the unit of analysis by one level upwards as properties of localisation of function emerged. It will be taken here that emergent properties indicate that a new

level of analysis has been reached, thus taking a functional rather than structural approach. Unfortunately the demarcation line between one level and the next, and between one scientific domain and the next can be rather vague, especially when more than one type of discipline can lay claim to the same observed content. The large number of neurons (ten billion) in the brain could lead the researcher to believe that many of the secrets of human behaviour would be encoded within. With the progression from localisation of function to larger units such as the cortexes, the brain as a whole presents a deeply complex series of systems through which theories at different levels from biology down can postulate theoretical entities. This view of the biological unit as a self-contained whole is one which will be returned to later.

A Hierarchy of Systems.

This topic, dealt with again in Chapter Five by being contrasted with a hierarchy of sciences, is one which considers the world to be a set of systems at many levels that interact in ordered yet highly complex ways. Systems are seen as real entities that can be observed with varying degrees of success by levels of theories, and comprise the content of the various levels of theory. Systems are thus seen to produce the stimuli for observation. The hierarchy of systems is not a conventional ladder-type hierarchy as the hierarchy of sciences presents, instead it runs from the top downwards in a sort of inverted tree (Koestler, 1967). This reflects the increasing generality of the contents of disciplines lower on the hierarchy of sciences. Seeing a phenomenon at any level, for example alcoholism, as a product of interlocking systems at levels above and below the psychological level presents a methodologically more difficult task than the reductive paradigm prescribes, since no clear direction in which to move is outlined.

Several levels appear as possible explanatory sources for this example: 1) possible genetic factors; 2) physiological dependence; 3) behavioural acquisition and maintenance; 4) norms on social drinking; and 5) inequities in the power structure of society. Note that the list ascends levels of systems in linear fashion. To attempt to take all such levels into account presents a scientist/practitioner with a quandary that may not affect either a scientist or a practitioner. The problem lies in the constraints set by the scientific method that was developed in the reductive mode. In order to deal with the problem in a complete manner, several levels may need to be taken into account, but this interferes with the requirement of science to produce well-controlled data that manipulates or tests one variable whilst controlling all others (to a certain extent, this is where the hierarchy of systems, requiring a multi-level approach comes into conflict with the hierarchy of sciences which requires a rigorous, controlled approach).

The reductive tradition in psychology

would prescribe a downward search for the "controlling variables" of the alcoholic behaviour. In order to glean a scientifically respectable explanation and make sense of the mess of available data sources, the reductive tradition encourages a narrowing down of the field of enquiry to the next lower level. This facilitates the use of a univariate testing procedure that attempts to manipulate one independent variable whilst keeping all others constant. This tendency to control the rest of the world whilst focussing on target variables in a sort of vacuum is a type of reduction in itself that relies on single concepts at any level for explanatory purposes. The problems of external validity (generality) that the univariate tradition has brought to psychology will not be detailed here, although single concepts in psychology will get a cursory airing later in the chapter.

The Phylogenetic Continuum

The differential capabilities of biological organisms at differing points on the phylogenetic continuum is a concern of Koestler (1967). At the lower end of the continuum, the behavioural flexibility of the animals is limited, although they have a high ability to regenerate lost limbs and are able to exhibit adult behaviour much sooner than higher-order animals. Moving up the phylogenetic continuum, behavioural flexibility increases, with a decreasing ability to regenerate lost limbs, and a longer nurturance period. As will be seen later, as the behavioural flexibility of the higher-order animals diversifies, physiological reduction may become a less appropriate strategy for the investigation of psychological content.

Social Organisation and the Unit of Analysis

With animals such as termites and other social insects, there is a total dependence on the organised group as a whole, even though each insect is a distinct unit in the biological sense. Koestler (1967) claims that the social insects cannot be understood without reference to the hierarchical organisation which controls most aspects of their life. This implies that the individual does not constitute a suitable unit of analysis for the study of the social insects. As Koestler (1967) puts it: "An individual is usually defined as an indivisible, self-contained unit, with a separate, independent existence of its own. But individuals in this absolute sense are nowhere to be found in Nature or society, just as we nowhere find absolute wholes. Instead of separateness and independence, there is co-operation and interdependence, running through the whole gamut, from physical symbiosis to the cohesive bonds of the swarm, hive, shoal, flock, herd, family, society "(p67). Thus the status of the individual as a suitable unit of analysis at any level is called into question by Koestler. The implications of this for psychology will be developed over the next few pages. With

increasing levels of the phylogenetic continuum, animals exhibit increased behavioural flexibility and an increasing amount of independence from the social organisation around them Also, the increasing complexity of the internal organisation of the biological unit in this direction gives the scientist a lot to study without taking wider social or structural considerations into account.

It is contended here that in the direction of increasing autonomy on the phylogenetic scale, the increasing complexity of the levels of systems within the organism has led to the biological unit being seen as the suitable unit of analysis for psychology. This section represents an attempt to show that the individual as the unit of analysis in psychology is an arbitrary restriction in terms of the hierarchy of systems. This restriction is of course not arbitrary in terms of the pragmatic constraints on scientific philosophy and method. According to Koestler (1967) the world could better be seen from a twin perspective: in terms of the given subject matter being a whole in itself (the individualistic perspective) and at the same time part of a larger system. This recognises a "hierarchically organised world" that Koestler argues for, and represents a sort of "top-down" way of interpreting causal chains. He argues for a downward determination from higher-level trigger-like causes to more widely-spread phenomena at lower levels. Non-specific precipitants at higher levels are seen to control or guide the more widely distributed but more specialised phenomena at lower levels. Koestler's example of the analysis of speech behaviour illustrates the epistemology of his approach. He makes the point that speech is a rule-governed behaviour where the speaker is largely unaware of the lower-level problems (such as muscle co-ordination) that speech presents. Indeed, Koestler speculates that a reductive account of speech may well conclude that speech is not possible!. A simplified version of the causal chain involves: "converting the potentialities of an idea into into the actual motion-patterns of the vocal chords"(p41). By interpreting the world in terms of causal hierarchies which act from the top-down, Koestler attempts to show that reductive explanations do an inadequate explanatory job. The twin-aspect view of scientific content as both a whole in itself and part of a larger whole leaves the hierarchy "open-ended", in that the top of the hierarchy is not defined - a sort of infinite regress.

Single Concepts in Psychology.

Single concepts in psychology represent a reductionist method of describing the subject matter of psychology in a vastly simplified manner. The term "single concept" will refer here to the narrowing of the scope of enquiry to a single type of "cause" that is seen to explain the phenomenon in question. Single concepts can be an integral part of modelling in science (discussed in Chapter Five), where an unknown phenomenon is reduced to

a known process.

An example of a single concept in social psychology is the cost-benefit analysis that may be applied to the development of dating relationships (Berscheid, 1985) in order to predict whether or not a relationship will continue. The single concept here is the rational (micro) economic model of human nature. Another example is the catch-all concept of "cognitive dissonance" (Festinger, 1957), a theory that sees cognitions about a person or object as being dissonant when there is some sort of illogicality or incompatibility between them. Applications of this sort are prone to commit a sort of nominal fallacy - merely labelling a cognitive state without actually explaining it. The state of cognitive dissonance is not well defined but it is relatively easy to produce. A final example of a single concept can be found in sociobiology, which is predicated on on the concept of genetic propagation, reducing behaviour to this concept. Single concepts also are convenient vehicles for post-hoc theorising - you can only interpret cognitive dissonance retrospectively, as with reinforcement theory. Computing models can be considered a "single concept" in that they reduce the complexities of psychology to binary logic, however this is an oversimplification, and computer models will get a more sympathetic airing in Chapter Five.

The behavioural tradition in psychology, in spite of being a within-level paradigm, reduces the complexities of behaviour to the principle of reinforcement, gaining little sympathy from Koestler (1967). Although it is not the intention here to echo Koestler's trenchant diatribe against behaviourism, two points emerge which apply to the Skinnerian behaviourism that also apply to the single concepts mentioned above. These points attempt to illustrate the explanatory inadequacy of single concepts in psychology.

Firstly, the obvious point is that single concepts do not provide the researcher with data that enables the complexities of everyday behaviour to be represented by academic psychology. The laboratory technique that follows from the demands of science, and use of lower-order mammals[1] in some fields, abstract the subject matter to an extent that renders reconstruction or synthesis impossible. In short, the bottom-up analysis does not enable sufficient building-up to be done once the parts are separated.

In defence of the behavioural paradigm, it takes as something of an epistemological principle that the best way to gain knowledge is to break down behaviour into its constituents, an effort to simplify the behavioural complexities. This is diametrically opposed to the sort of paradigm outlined by Koestler which takes the complexities of behaviour as something to be *preserved*. Thus although the methodological implications arising from the two paradigms appear to be in conflict, the two

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[1] The use of "animal models" as explanatory vehicles in psychology is also a form of reductionism from higher to lower forms on the phylogenetic continuum.

do not communicate with each other due to the disparity in epistemological outlook. The two outlooks differ in a fundamental way, therefore it would be unfair to judge one from the outlook of the other.

The second point that arises in a discussion of single concepts in psychology is that single concepts are often sourced in a lower-level science in a bid to help simplify the complexities of social science. Since the biological beast is is found at the next lower discipline from psychology, single concepts in psychology that model the processes of the biological beast find themselves welcome in an individualistic ethos.

More on Individualism

The twin-aspect outlook outlined in the section on a hierarchy of systems carries the methodological insecurities of the "globalist" (Harth,1982) approach, but allows the reductive analysis a complementary[2] role in the explanatory picture. Harth's globalism refers to the collective effects of ten billion neurons being taken into account to avoid the explanatory impoverishment of the mono-neural analysis, but the term "globalism" is extended here to refer to the global or wider societal aspects of the top-down approach, an approach that a natural scientist like the physicist Hodgson (1985) would see as dangerous due to the unfruitful directions in which the non-reductive pursuits lead (an historical outlook can present reductionism in a rather favourable light, but as seen in Chapter Three, the explanatory framework of reductionism may be currently overtaxed).

As with reductive explanations, individualist explanations may have a complementary role in the explanatory picture, even at an impersonal social level. Even if a reference to individuals is not seen as providing a full explanation, a strong argument can be made that a full or complete explanation is not possible without some reference to individuals (Kincaid, 1986). Individualism, although implying a biological unit, can refer to the unit of analysis in social psychology - the field still measures the biological unit and its inputs (see Chapter Two and the limitations of the "open system" approach). The aggregate statistics of groups of people in social psychology, by being based on individual scores, appears to lose touch with even the meagre benefits of individualistic analysis without synthesising higher-level knowledge, thus appearing to leave concepts such as "the false consensus effect" (Ross, Greene & House, 1977) on uncertain ground.

Individualism is a form of reductionism especially when referring to phenomena that have political/structural implications. An example of an individualistic explanation in a political context would be a psychological or aggression-based explanation for international conflict.

The negative political implications that

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[2] A possible complementary role for reductive results will be developed in the section on "derivation-reduction" in Chapter Five.

an individualist analysis provides include the fact that the explanation for human behaviour can be found by looking inside the organism. Issues of blame arise here, wherein lies a paradox provided by societal-level organisation: blame is accorded to individuals in spite of the deterministic links sought by the scientific world, links which theoretically absolve actors of a large portion of the blame. However, the intention here is not to critique reductionism or individualism on political grounds. Rather, it is intended to assess the individualistic paradigm from the perspective of whether or not it provides an adequate explanation in psychology. The reductive implications of an individualistic unit of analysis would suggest not.

However the main individualist question in psychology is whether or not the psychological animal can be understood by reference to individual factors. In the light of the section on the hierarchy of systems it is contended that there are aspects of psychology that are not reducible to the measurable characteristics of the biological unit. For example, the routine behaviour of working people in western society may not be reduced to the individual characteristics of each person. With such trans-personal monotony evident across the world, an analysis of political or even business structure would constitute a more fruitful line of enquiry. Llewelyn and Kelly (1980) point out that "the fact that we all talk the same language, in itself challenges the status of our individuality"p(410). Does this threaten the status of psychology as a discipline? Probably not, since the reductive definition of psychology is set by the upper limit - i.e. the name "psychology" sets psychology as the highest content level. It is apparently, by this definition, permissible to reduce to lower-level sciences without losing a disciplinary identity. As long as the phenomena to be explained lie at the psychological level, then there should be no problem with explanations that sample a range of levels.

Summary

This chapter has attempted to cover a wide range of issues regarding the notion of levels of sciences and levels of systems. The separation between the concepts of a hierarchy of sciences and a hierarchy of systems was maintained following the "realist" distinction in Chapter Three between the theoretical outlook of the observer, and an assumed worldly reality that supplies the content or subject matter of the sciences.

The hierarchy of the sciences involves an ordering of the sciences according to complexity looking up, or according to simplicity or generality looking down. Although the hierarchy presented as a list running from physics or sub-atomic physics through chemistry and biology to psychology and sociology appears like a ladder, the *systems* that the disciplines represent can better be conceptualised as a sort of inverted tree, where the generalised "commands" at the top precipitate action in increasingly

smaller units of analysis at lower levels.

Note that the *generalised* higher concepts "ideas"are seen here to flow down to specific lower concepts "motor neurons", although the systems at lower levels are more widely distributed, and talk of the content of lower-level systems refers to the generality or wide applicability of the lower-level system. The hierarchy of sciences becomes increasingly complex in the downward direction only in the sense that increasingly smaller units of analysis reveal new and more intricate research questions, otherwise the term complexity is used here to the increasing number of levels within higher-level theories and systems. A downwardly determinative approach is endorsed here in contrast to the traditonal reductive route which can be seen as "upwardly determinative" by studying parts in isolation.

The indeterminacies of quantum level physics and the effects of chaos are difficult to ignore. These indeterminacies carry negative implications for the possibility of successful translations between scientific levels. These translation issues are discussed in the next chapter. The change in emphasis in physics from structures to energy fields can be seen to model for psychology a shift away from the search for lower-level physical determinants of behaviour (Llewelyn & Kelly, 1980).

As the unit of analysis increases in scope with biological organisms higher on the phylogenetic continuum, the complexity of the internal systems that emerge provides the scientist with many research questions to answer. It is contended here that the biological unit in psychology represents an arbitrary restriction on the scope of the unit of analysis, and that the model of the world's systems as being hierarchically ordered from higher generalised systems to lower specialised levels paves the way for a twin-aspect view (after Koestler) of the unit of analysis that sees a given phenomena in any discipline as part of a larger system, and also a system in itself. This view improves on the deficits of the "open system" approach mentioned in Chapter Two by allowing the unit of analysis to transcend the individual if this helps the explanation. The globalist excesses of downward determination have been tempered by the components of a given unit of analysis being granted a complementary role in the explanatory picture.

CHAPTER FIVE

Epistemological Issues in Reductionism

Introduction

This chapter will attempt to deal with reduction as divided into three separate categories regarding knowledge, facts and method. A broad definition of each of the three terms epistemological, ontological and methodological reductionism will be followed by a discussion of the first two terms. A discussion of wholes, sums and parts will be followed by an analysis of reductive models in psychology. This chapter attempts to describe translation difficulties that prevent the lower-level disciplines on the hierarchy of sciences from being "built up" to comprise the higher-level disciplines.

Epistemological Reductionism

The word "epistemology" means "theories of knowledge". The substance of epistemological discussion is an attempt to say how we come to know about the world. Theories of knowledge are seen here as an essentially linguistic exercise, and can be considered in abstraction from worldly phenomena. Reductionism is epistemological in that it postulates a particular way of knowing about the world as being a better explanation than a within-level explanation. This superior knowledge is obtained by reference to a more basic knowledge - taking knowledge at one "level" of science and reducing it to that of a lower level. With reduction then, the chief epistemological exercise is to "explain" or render more intelligible data[1] at one level with reference to a science at another level. The epistemological question in this chapter is whether or not the terms of one science can be translated into the terms of another science. If this were possible to a high enough degree, then in theory, higher levels of science would become redundant. Reductionist translations in science A that reduce to science B work to render science A redundant, although the initial problems or questions

[1] Note that Chapter Three distinguishes data from an assumed worldly reality.

are couched in terms of science A. Epistemological claims include "everything can be reduced/explained by mathematics" or "higher level sciences can be reduced to physics". Clark (1980) writes about three types of reduction; 1) Eliminative reduction; 2) Derivation-reduction; and 3) Model-reduction. The first two were introduced in Chapter Two, and will be discussed here in the section on epistemological reductionism.

Ontological Reductionism and Identity Theory

The word "ontology" refers to theories of facts, or theories of "how the world is". An ontologically reductionist claim would be something like "phenomena at level A are 'nothing but' phenomena at level B". The ontological reductionist would claim that a "complete knowledge" of the *entities* at lower level B are sufficient to gain a complete knowledge of the entities at higher level A, without investigating the higher level entities. This is an extreme philosophical position that denies any emergent properties of higher levels of organisation, and in practice is diluted to "a partial knowledge of the entities at lower level B is sufficient to dispense with investigation at higher level A".

There is a problem with the extreme form of ontological reductionism that holds that something like "depression" is in fact "biology". By saying that one discipline is in fact the other, the higher-level discipline is rendered redundant and it becomes meaningless to use the terms of the higher-level discipline. This problem is seen here to affect the identity theory of psychological states.

Regarding identity theory, by saying that a sensation *is* the firing of a neuron, it is possible to interpret from this that the neuron is a sentient entity that knows the psychological nature of the task it is involved in Harth (1982). This represents an extreme form of the faith in the reductive paradigm's ability to provide adequate explanation. Harth refers to such reasoning as a category mistake, which regards talk of perception and talk of electrochemical processes as mutually exclusive categories, in spite of the reductive implication that there is no difference between the two. Rose (1982) writes in a similar vein: "...the interpretation at each level requires concepts which are themselves only appropriate to that level... *genes* are not spiteful or altruistic, *assemblages of cells* cannot learn, love or be angry; such terms are inappropriate to the genic or physiological levels of analysis, but appropriate to the whole organism" (Rose, 1982, p13). This problem with identity theory echoes a fundamental inadequacy of reductive analysis, being that the higher-level content is lost in the downward transgression of disciplinary barriers. For this reason, the identity theory of psychological states will not be examined at length here.

Methodological Reductionism

This is interpreted here as referring to the investigative method that follows from reductionist principles. The term "methodological" refers to the theoretical imperative that atomistic or reductive methods are the best means which which to study the world in order to provide the explanation sought. This type of reductionism was largely the subject of Chapter Two, and involves the measurement and quantification of states and processes at a level seen as more basic in terms of a hierarchy of sciences. In general, wholes are broken down into parts and the parts are studied, (with an intention) to build up from the micro to the macro level (Peacocke, 1976). This conceptual framework may include among its exponents the hard core of reductionists who cling to the belief that reductive difficulties are due solely to present incompleteness in technical knowledge, and believe that all the sciences will be reduced to physics and chemistry (Peacocke, 1976).

Epistemological Issues in Reduction: Eliminative Reduction

Epistemological reductionism is essentially a question of the ability to translate between two different sciences, usually at adjacent levels in the hierarchy of sciences. The typical presentation of the problem comprises the form of a linguistic identity relation between two sciences. An extreme form of epistemological reduction is eliminative-reduction (Clark,1980), where if the terms or sentences of one theory can be shown to be special cases of the terms or sentences of another theory at a lower level, then a successful reduction can be said to be made. Put more formally (adapted from Clark, 1980):

1) The reducing theory explains all of the observations explained by the reduced theory T', and may explain more since the lower level science is more general in its application. The reference to neural states also involves a more precise account of the reduced phenomena.

2) The reduced theory and the reducing theory employ radically different conceptual frameworks. Terms in each theory are linked to different observations, and the two theoretical approaches describe different things.

3) Some assumptions of the reduced theory are rendered false. Higher level theories are not relevant to the problem. According to Clark: "Theoretical terms in the two theories for this reason cannot be related to each other without either falsity or contradiction"(p26).

4) The success of the reducing theory T enables us to reject the reduced theory T' and cease to employ its theoretical terms, with simple replacement of the theoretical framework involved.

These points illustrate a view of reduction that sees two theoretical outlooks at different scientific levels as providing incompatible explanations of psychological or indeed any phenomena. The eliminative re-

ductionism represented here demands that either one or the other scientific level provide an account of the phenomenon in question, that excludes the other explanation in a competitive manner. Common examples of such eliminative reductionism include the statement that "depression as a theoretical problem involves depletion of biogenic amines in the sympathetic region of the brain", or "a knowledge of the response contingencies in the external environment eliminates the need for explanations that involve reference to private mental events". The former statement can be easily converted to a statement of ontological reductionism by restating it thus: " depression is *nothing but* the depletion of biogenic amines in the brain". This subtle distinction between these two statements is made because scientific theory or observation, as seen in Chapter Three, is unable to provide "givens" that provide an immutable knowledge-base. This leads on to the point that ontological claims regarding the status of a problem as "biological" or "psychological" are on dubious foundations. It would be safer, therefore, to couch knowledge-claims in terms of theory, for example one could say that "depression is a problem of neural models". This still leaves us with an analysis that might be called eliminative reductionism, however it is not as material as the ontological claim. An allowance is not made here for the ontological reductionists who say " X is nothing but Y" that immediately assumes their claims to be *theoretical.* Thus a bald ontological claim is treated here at face value, and disagreed with as such.

Assessment

One of the key questions in the assessment of the eliminative-reductive view is whether or not the terms of one science, theory or paradigm can be translated into the terms of a science, theory or paradigm at another level. Although there is an extensive literature on reductionism, writers in defence of reductionism are not easily found. Exceptions to this include the pro-reductive articles by Popper (1974) and Eccles (1974). A negative bias appears in articles that discuss reductionism; writers that find occasion to discuss reductionism tend to talk about the feasibility of (e.g.Jessor, 1958), and problems with reducing the terms of one science to another science. This literature responds to (or makes explicit) aspects of science that are implicit in the research methodology available. In a sense, literature on the merits of reductive strategies is not needed in defence of reductionism, because the philosophy is already endorsed in the research strategies. Also, the topic of reductionism can be discussed without the writer using the term "reductionism" at all (Thorpe, 1974). Reductionism is also an implicit issue on writings on consciousness, individualism in psychology and the mind-body problem.

The feasibility of translation between the two sciences does not, however, hold the

key to the "problem of reductionism". One of the main objectives of this thesis is to assess reductionism on grounds that go beyond the epistemological issues of linguistic translation between sciences. Some of these grounds became evident in Chapter Four in the discussion on individualism in psychology. The translation problem from one science to another will be discussed in the section on derivation-reduction, with the discussion concentrating on such things as "connecting principles" and "identity statements".

Theoretical frameworks

Reductive arguments can involve changing the theoretical framework, for example from psychology to physiology, from Aristotelian to Copernican astronomy, from religious to Newtonian to Relativistic physics, or from "indirect" to "direct" perception (Michaels and Carello, 1981). In each case the theoretical framework has changed as a result of the inadequacies of the old framework being an obstacle to knowledge advancement. Theoretical frameworks set the parameters of the questions being asked (Chapter Three).

The reductive explanation that eliminates one level of theorising in favour of another often involves replacing "common sense" with another explanation, usually with a more materialistic bias. The common sense explanation is seen to be redundant with regard to the cause of a given phenomenon. Reductive analysis can also give a new type of explanation, or as mentioned before, can present a new theoretical framework. The explanatory account could be changed by a reductive account from a descriptive to an attempted causative account, or the change may be from one causative account to another. The reductive account enables us to debunk the false correlations that arise in common-sense thinking, and in psychology may provide the third variable that links two closely correlated observed phenomena. Elsewhere in psychology, the third variable is known as a problem which interferes with univariate manipulations and results in uncertainty of causal inference in investigations that are limited to one regressive step. The two senses of the term "third variable" are a result of the vagueness of the term.

Two differing theoretical outlooks can offer postulates regarding differing places in the causal chain. A physiological account differs from a psychological or behavioural account in that the physiological outlook concerns internal workings, whereas the behavioural outlook spans the physiological events. Thus the eliminative view chooses between causes that emanate from differing domains, one external to the organism, and the other internal.

As noted in Chapter Three, "leaps ahead" in science are seen here to occur as a result of the conceptual frameworks being pushed to the limit. The different conceptual frameworks between the psychological terms and the physiological terms render, from an eliminative perspective, each

framework mutually exclusive. This is a situation where the reductive insight can change the nature of the explanatory framework. Clark (1980) sees psychological and physiological accounts to be not merely rival theories, but instances of different theoretical frameworks. Thus Clark sees a reductive explanation as providing an explanation that stretches the old theoretical framework to the limit. This is in contrast to the view taken here in Chapter Three which sees reductive explanations as perpetuating a particular conceptual framework, i.e. reductive epistemology. Whilst scientific reduction has helped to change some medieval conceptions of the world, reductive arguments form a conceptual framework in themselves that may, in this latter part of the twentieth century, need to be replaced, as the reductive framework fails to cope with the data emerging from a multi-level world.

Elimination and Replacement

The elimination of psychological-level explanations with the use of physiological-level explanations involves a *replacement assumption* (Clark,1980) that says: "If a theory T' reduces to a theory T, then any explanation using a term from T' can be replaced by some explanation using a term or terms from T"(p24).

This replacement assumption underlies an extreme reductive position, and involves the use of sentences as explanations. It assumes that physiological terms can replace psychological terms, and although psychological or common-sense terms can still be used, they can be dispensed with very easily (Rorty, 1970).

Clark (1980) argues for the ineliminability of psychological terms. According to Clark, a close set of identity statements, with strict localisation of function facilitates a fairly complete reduction. However Clark claims that the psychological explanations are important to keep because the descriptive and explanatory contexts are different. The value judgement that emerges from this is that the psychological account with its different descriptive and explanatory contexts has some value over and above simply being distinctive. This value that the psychological contexts have over physiological or lower-level contexts constitute barriers to eliminative-reduction:

1) The purely physiological description does not make clear the connection between the physical process and the behaviour in question.

2) The meaning of a given psychological term is that the psychological state has certain relations to stimulus variables, to other variables, and to response variables. We need *functional* terms to determine the relations between the stimulus conditions, internal states and behaviour.

For Clark, then, functional terms hold the key to relating psychological terms to physiological terms in a manner that renders reduction successful.

Derivation-reduction

This position treats reduction as a derivation of one science or level of theory from another. The factual statements in physical terms from a derivation-reduction point of view are complementary to the factual statements in the higher-level science. In this derivative sense, physiological information can "back up" the observations made in psychology. This can be done in at least two ways. Firstly, the physiological findings can confirm the psychological statements by the observed action of neural or other physiological structures that are already implicated in the given behaviour. The confirmation of activation of a structure known to be involved in a given psychological process may be useful in a diagnostic sense. A second way that a lower-level science can complement a higher-level science is through the discovery or explication of structures at a lower level that are seen to be involved with the higher-level process.

The derivation of a lower-level science from a higher-level science involves the assumption that some sort of general identities exist. These general identities connect a state represented by science A to a state represented by science B. For example, depression in psychology may be represented as a depletion of brain NE in certain areas of the brain. The logical derivation from a higher-level science to a lower-level science involves the use of "connecting principles" which, according to Clark (1980) are general identities. The general identities act as connecting principles.

General Identities and Connecting Principles

A general identity is a type of statement that links two classes (Clark,1980) of theory, and the establishment of general identities are seen by Clark as being important for the derivation-reduction view, in that they should enable some communication between the two levels of theory.

The connecting principles that enable reduction between two scientific languages involve necessary and sufficient conditions for the derivation to succeed. Clark (1980) states that the best forms of connecting principle that we have at the moment are of the type "The ventromedial hypothalamus is the satiety centre". This statement connects the physiological term "ventromedial hypothalamus" to the psychological term "satiety". Thus according to Clark, the best statement of a general identity we have is one of *localisation of function,* (Chapter Two) which connects the higher-level psychological terms to the lower-level physiological terms. Localising a concept such as "satiety" to the area of the "ventromedial hypothalamus" enables the psychological function to be assigned to the physiological apparatus or state.

In Clark's analysis, there is an implicit assumption that in statements like "The ventromedial hypothalamus is the satiety centre" one takes the ontological statement

(of fact) and gives it epistemological status. The best way of knowing about the world is through reduction to a lower level science, according to epistemological reductionism. Since Clark treats reduction as a linguistic (or epistemological) exercise, the claim that the ventromedial hypothalamus is the satiety centre presents an ontological rather than an epistemological or linguistic view. The problem seen here is that there is no cognisance of a distinction between theories of facts and theories of knowledge. The Clark material appears to take reduction as a methodology (localising function) and mistake it for reduction as an epistemology, whereas this thesis has represented an attempt to keep the two uses separate. The literature on reductionism often does not make clear distinctions between the many different senses of the term "reductionism".

Some Problems of Epistemology.

The most obvious, and best documented epistemological problem lies in the translation problem between two levels of scientific discourse. Supposing that localisation of function were possible to a high degree, and that higher-level theoretical content could be assigned to the lower-level states. Questions emerge as to what it means to assign psychological content to a physiological state, and also whether or not it is important to retain meaning or functional significance in a reductive explanation.

When reducing a psychological phenomenon or concept to a physiological state for explanatory purposes, the meaning of the terms used undergoes some change. For example, in the Jessor (1958) arm-waving example, an explication of physiological events involved with arm-waving leaves out the functional significance of the psychological act. This inability of one science to be adequately derived from the other is an essential feature of the anti-reductionist argument.

Jessor (1958) argues that a discipline such as physiology lacks the contextual terms that lead to the development of laws in psychology that refer to "..interactions between organisms and functionally defined environments..."(p174). Jessor refers to reductionism as a problem of *logical equivalence* between two different levels of science: "The barriers (to reductionism) reside in the absence of terms in the "lower" discipline which would enable the logical derivability of descriptions of the functional context of behaviour and, thereby, the derivation of the laws of psychology."(p175).

Gaito (1960) considers Jessor's argument to be lacking on the grounds that Jessor did not distinguish between *explanation* and *description*. Gaito claims that reductionism makes for poor description but good explanation. The logical barriers to perfect reduction are recognised by Gaito, although he contends that reductive analysis is ideal for explanatory purposes, which he sees as involving seeking out the "atoms" of behaviour. Consequently, it is obvious that

Gaito's (impoverished) view of explanation as an atomistic pursuit renders the reductive paradigm acceptable.

The Logic of Reduction, Systems, and the Part-Whole Distinction

When there is talk of "the logic of reduction" or "the logic of functional isomorphism", or when reduction is treated as a linguistic problem of translation between sciences , it is contended here that this approach misrepresents the problem of reduction to a certain extent by omitting to mention the methodological manifestations of reductionist epistemology. Beckner (1974) called for a similar distinction between: "...(a) the logical relations that hold between theories, descriptions, conceptual schemes and other instances of language; and (b) what we may as well call real relations (causal, identity, spatial, temporal, part-whole etc) between the events and other phenomena that our languages describe."(p174).

This sort of reasoning has developed quite independently of the actual feasibility of the logical relations between two levels of theory or science. Beckner (1974) contends that if the the strongest possible formulation of the reductionist thesis were true, then researchers would not automatically study only the lower-level sciences, due to the directions and hints that flow down from higher-level theories. Conversely, a recognition of any ultimate irreducibility of terms from one theory to another need not exclude the possibility that a reductive analysis is appropriate. Since Beckner (1974) points out that a reductive analysis benefits a science through the directions, hints etc that flow down from the higher-level theories, the higher-level theories can provide the sort of complementary information that Clark (1980) describes in the definition of derivation-reduction outlined earlier in this chapter. Beckner's flow-down view of reduction can also provide the sort of higher-level context that is required by the Jessor (1958) critique of reductionist explanation in psychology. By treating reduction as a derivational rather than an eliminative exercise, the reductive analysis emerges in a more constructive light. This highlights a theme in Chapter Three, that the suitability of a given analytic paradigm (and therefore method) depends on certain theoretical attitudes that are held before the data collection commences. After Beckner, the reductive analysis appears to have more to contribute if the information yielded is simply considered as complementary rather than exclusionary. This concurs with the common-sense view that different sources of data (from different levels) can provide a more complete picture of the target phenomenon.

Campbell (1974) uses the term "downward causation", to describe, how in biology the laws of the higher-level world

(e.g. natural selection) determine the *distribution* of lower-level events and substances. Causation is seen by Campbell as running downward only if the temporal unit of analysis is large enough to span several reproductive generations. Such direction is lacking in the instantaneous causal analyses derived from (older) physics (Campbell, 1974). This change in the size of the unit of analysis from instantaneous to longer term moves in the direction of the Gibson (1979) conception of time as being relative to *events*. Gibson sees the reality underlying the dimension of time as events, not time as as the underlying constant behind events. By taking instantaneous snap-shot measures, the reductionist obscures the higher-level context of the target phenomenon, and leaves structure and function as salient units of analysis.

Gibson (1979), referring to ecological events, claims that there exist regularities at the higher-level that cannot be encompassed by the laws of mechanics and physics. The elicitation of higher-level laws is significant for such writers as Gibson, Koestler, Beckner and Campbell. Given that higher-level laws are available through an expansion of the temporal unit of analysis, these writers see some value in making such laws reasonable goals of scientific enquiry.

A distinction was made earlier (from Beckner 1974) between logical relations (between theories) and so-called "real relations" between events. This distinction is also recognised by Peacocke (1976) who made a distinction between a hierarchy of natural systems and a hierarchy of natural sciences. This distinction recognises a difference between the events and things of the world, and the tools available to investigate the world, i.e. theory. Systems are taken in this analysis as being assumed to exist independently of the theoretical outlook imposed by observation. Peacocke sees theory-reduction as an essentially linguistic exercise and not "...the derivation of the properties of one subject matter from the properties of another - because the 'nature' of things (especially the elementary constituents of things) is not accessible to direct inspection" (Peacocke, 1976, p320).

Autonomy of Higher-Level Theories and Systems

"Autonomy" is a concept that attempts to describe the non-reducibility of higher-level theories or systems. A higher-level system or process S_h is seen as autonomous from a lower-level System or process S_l if the parts that make up S_l are not sufficient to also compose the parts that make up S_h. Conversely, a higher-level theory T_h is autonomous with respect to a lower-level theory T_l if the terms of the T_h are not reducible to the terms of T_l. This latter problem is the chief epistemological problem of the present chapter.

The autonomy of higher-level theories or systems is a concept that bears some resemblance to three other terms found in biological writing. "Emergence" is a term that de-

scribes the properties that appear as the hierarchy of sciences is ascended. For example, in chemistry, sodium and chlorine both have poisonous properties whereas their synthesis results in the non-poisonous substance salt. In psychology, the psychological or social context is usually unable to be encoded in physiological terms. The second term, "vitalism" is a term that refers to a non-physical control mechanism such as the mind that has been seen to play some causal part in the behaviour of biological organisms. This non-physical entity, a legacy of Descartes, represents an emergent property of the biological unit. The third emergence-related term to be mentioned here is "organic unity", which refers to the unit of analysis as being not reducible to the sum of its parts.

When distinguishing between hierarchies of systems and hierarchies of theories, Beckner (1974) makes a distinction between "process" autonomy and "theory" autonomy. By making the distinction between hierarchies of systems and hierarchies of theories, Beckner shows that the autonomy of higher-level processes does not follow from theory autonomy, because theory irreducibility may be due to differences in the *conceptual structure* of the two theories, and not to lack any of determination of processes in levels of systems (Peacocke,1976). Thus the inability of the scientific world to penetrate the systems of the ontic world is a salient issue again. Beckner (1974) considers it a fallacy to think that if a phenomenon P at level i (P_i) is exhaustively composed of parts P_{i-1}, then any theory T_i is must be reducible to T_{i-1}. He sees this fallacy as being one that "has consistently been opposed by the organicist and vitalist traditions"p168.

This distinction between hierarchies of systems and hierarchies of theories enables one to gain some insight into the special character of hierarchies of theories. However, this distinction does carry with it a certain problem. Although it refers to a dichotomy between process and theory, the act of writing about it renders both process and theory as linguistic phenomena. There is a certain irony in making such a distinction, due to the necessity to use language to report it. Scientific enquiry binds systems with theories by reducing systems to the theoretical level. Although this thesis is not considered to be a piece of scientific enquiry, the linguistic, theoretical mode of talking about the world constrains this thesis as it would any other piece of academic enquiry.

Model-Reduction.

The term "model" has many different senses in academic as well as popular use, and a common use of models in psychology is in Harré's (1970) sense of the word "paramorphic". Although Harré provides a comprehensive taxonomy of models in science (including homeomorphic, iconic and sentential models), the paramorphic model

is selected here due to its reductive popularity in psychology. A paramorphic model is one which describes some hypothetical mechanism or system which helps to explain in a particular way the target phenomenon as if it were like the source of the model. Paramorphic models work through analogy. In the research context in psychology the model represents some system or phenomenon that is well understood, and is used by analogy to explain the target phenomenon

With paramorphic modelling, the structure of the model is not claimed to be the same as that of the mechanism being modeled, and the form or process is also not claimed to be same - hence the "as-if" clause that relates process by analogy. An example is the Lorenz action-specific energy model, which models the nervous system on a fluid reserve (supplied by a tap) which accumulates to represent the available (action-specific) energy of an organism at any given moment. External stimulation combines with internal pressure to result in the release of this energy in behaviour through the releasing mechanism (Clark, 1980). Behaviour is not claimed by this model to be mediated by a liquid reservoir filling up to overflow point. Thus neither structure (hydraulic mechanism) nor process (overflow) are meant to be literal postulations.

Some overflow of a certain type of energy is postulated, but it is not the same as overflowing water, merely analogous to the underlying mechanism - hence the term "para" which indicates the form to be different.

Reduction through Modelling.

With paramorphic models, the unknown "subject" is a mechanism or system that is somehow hidden or not observable. It is the role of the model to represent the subject, and this is done by reference or analogy to a process that *is* known. The known process or system can be called the "source", from which the inferences about the subject are derived. The essence of modelling lies in the application of source-knowledge to the subject in order to better understand not the structure but the dynamic aspects of the subject. There is an emphasis on process and function with an attempt to gain some sort of functional isomorphism (Clark,1980) between source and subject.

Models in the paramorphic form, by taking a known process or system and applying it to the unknown subject are *reducing* the unknown to the known. This takes science ahead by small conservative steps, and as seen in Chapter Three, eventually stretches a theoretical framework to the limit of explanatory usefulness by virtue of the (reductive) method being less and less able to cope with anomalous observations. The small conservative steps that model-reduction encourages are consistent with Manicas and Secord's (1983) standard view of science outlined in Chapter Three.

Models in the sense outlined above are essentially reductive tools. If the reductive paradigm involves a search for hidden generative mechanisms, then models provide an ideal tool for this approach. Thus far, the analysis has been no more specific than to state that the "unknown" is reduced to the "known". Clark (1980) is somewhat more specific, saying that reduction is a matter of finding a *model* in one discipline for a *theory* in another discipline. Thus Clark claims that models cross disciplinary boundaries.

The reductive implications of the recourse to models mean that explanations for phenomena in the psychological domain are readily sought in the biological domain, which was seen in Chapter Four as the level immediately below psychology in the hierarchy of the sciences. Models, it is contended here, may have become popular in psychology due to the extent to which they facilitate reduction to disciplines that are seen in some sense as simpler than psychology. In "black box" modelling, the internal physiological apparatus is not represented as such. Some other field or discipline provides the model. This is contrasted with the purely reductive matter of translation problems between sciences. This translation does not involve modelling because of the attempt to establish true identities between the two sciences. Consequently, this thesis does not deal with terms like "a physiological model" of a psychological phenomenon. This use of the term "model" is seen as somewhat redundant if the explanation involves pure reduction from one level to the next. In this case, the term "theory" may be more appropriate.

Models may not necessarily be reductive in the sense of lower levels of sciences unless the subject is reduced to a known source. If the model happens to be sourced outside the current theoretical framework, such as with relativity theory, then the reductive implications may not apply.

The following section will provide an example of a modelling technique in psychology based on computing. A last point to make before this relates modelling to the single concepts discussed in Chapter Four, regards the direction of the reductive route in terms of levels of sciences. To place humanities and natural sciences on the same continuum seems somewhat inappropriate, and finding criteria by which to order them could force a contrived criterion. Perhaps some sort of parallel hierarchy would be more suitable. Anyway, when modelling psychological processes on such disciplines as micro-economics, mechanics or linguistics, the direction of the source in relation to psychology is unclear. This would appear bring into question the status of the explanation as reductive. Thus it is possible to consider the modelling relationship to be reductive if the source discipline provides a "single concept" such as with the reduction of psychology to the cost-benefit analysis derived from economics. Consequently the modelling relationship can be considered reductive even if the model is taken from a higher-level discipline. This can be known as "reduction upwards" (Lagersptez, 1984).

An Example: Computer Models in Psychology

Computer Models in psychology provide a good example of an application of paramorphic modelling. The subject consists of a hypothetical generative mechanism that lies within the biological unit. The phenomenon to be explained lies in the psychological domain, for example thought processes, memory recall, encoding, or forgetting. The source of the model comes from the computing field and can consist of some sort of processing hardware that accepts inputs and produces outputs in the same way that the psychological animal is seen to do, through an analogous process. Thus we are dealing with three disciplines: 1) psychology; 2) physiology (the field that mediates the inputs and outputs of the psychological or target level) and 3) computing, the discipline that provides the model that attempts to demonstrate some sort of functional isomorphism between computing and physiology.

Such a computer model can be thought of as being reductive in two ways. Firstly, it is reductive simply through being a more known quantity than the physiological workings of the biological unit, reducing to a supposedly more basic discipline. The second way that computer models can be thought of as reductive lies in the structure of the hardware that produces the outputs.

There are certain similarities between the structure of the nervous system and the structure of the computer. With the nervous system, a common unit of analysis seems to be the all-or-none response of the neuron, as seen in Chapter Two. Although this has become an inaccurate representation due to the discovery of graded neural responses (requiring a more qualitative analysis) the absolute measure has made a convenient unit of analysis. The relation that this all-or-none response has to computing is that the binary logic of the on-off electronic response is very similar. Thus the complexities of the computer are reduced to binary logic. Similarly, the complexities of the nervous system are reduced to the binary logic of the neuron.

This binary or functional similarity between neurons and computers has led to computers providing models of the nervous system. The reductionist problems such as translation difficulties and lack of a higher-level context appear to apply to the binary logic of the computer. As with the neuron, there is a problem of how the binary logic can represent the psychological phenomenon at the input-output level.

There are of course differences between the "pulse logic" of computing and the all-or-none response of the neuron, mainly that the neuron is far more complex than this, with graded thresholds, graded responses and thousands of inputs. The logic of the "impoverished neuron" (Harth,1982) thus arbitrarily ignores the legitimate electrochemical processes that underly the firing of the neuron.

However if it is accepted for argument's sake that the neural firing is a simple all-or-none process, and that we have a reason-

able computer model of some psychological phenomenon, do the reductive problems that plague the physiological reductionist also render the computer model inadequate due to the inadequacy of pulse logic to represent higher processes?

The analogy between neurophysiology and computing may throw some light on this question. Toward the end of Chapter Two the physiological discussion moved from the basic neuron to localisation of function. In the light of Chapter Four it can be seen that the subject matter in this case moves up a level of organisation, where the attribution of function differentiated different clusters of neurons. At this level (talking in millions of neurons) the quality of unique function emerges over the structural monotony of the basic neuron. Yet more properties emerge (balance of forces, feedback loops etc) as the analysis encompasses more and more of the brain structure as a whole.

Likewise, the binary logic of the computer should not reasonably be expected to carry the burden of psychological identity or representation. This writer's minimal understanding of computing processes is that there are several levels of organisation within a computer known as languages, which start from the bottom at the binary level (machine language), progress through assembly language, and further through to high-level languages, the highest of which communicates with the human operator, possibly in the natural language (e.g. english) of the operator.

Although the higher levels of computing language may or may not be reducible to increasingly lower levels of organisation, the output level language communicates with the user in a form that is sophisticated enough to render the binary translation psychologically meaningless. It would appear that when reducing computing to binary logic in order to claim that computer models are psychologically impoverished, the critic falls victim to their own tendency to be reductionist.

Binary logic alone, it is contended, is not enough to render computer models of psychological processes useless. Instead, if one wishes to evaluate paramorphic computer models in psychology, a more appropriate question might enquire as to whether the emergent properties of the two theoretical entities psychology and computing converge at increasingly higher levels of organisation. This discussion closes with an if-then proposition: If the properties of the two fields do converge at higher levels of organisation, then computing models may, by modelling the hierarchical organisation of the brain, have much to contribute to the field of psychology.

Summary

The purpose of this chapter was to attempt to tackle the questions of linguistic translation between different levels of theory. Theories are taken in abstraction from the systems of the world, following the literature on reductionism that considers transla-

tional issues to be the full extent of the problem of reductionism.

Eliminative-reduction represents an attempt to eliminate the higher-level explanation in favour of a lower-level explanation, and is an extreme version of the reductionist thesis. The new explanatory framework consists of the the theoretical restrictions of the lower-level science. In psychology, the localisation of function first mentioned in Chapter Two represents the general identities that link the psychological terms to the physiological terms.

The success or failure of reduction depends, from this perspective, on the degree of rigour demanded of the connecting principles. Even with rigorous connecting principles or identities, however, the eliminative perspective is difficult to maintain due to the absence of higher-level terms that provide psychological significance in the explanation. The derivational view carries more credibility by presenting less stringent demands on the reductive epistemology - the reductive information yielded serves to complement the knowledge at higher levels of knowledge.

The extent to which a theory at a lower level can be derived from a theory at a higher determines the success of reduction from the derivational perspective. The epistemological problems of translation between one level of theory and the next remain, however, but do not threaten the status of reductionism as they would for the eliminative perspective - if the psychological terms are there to stay, then the connection between these terms and the physiological terms do not need to be as strong as if elimination of psychological terms were the objective. The emphasis may shift, then, from eliminating the psychological terms in the eliminative view to assessing the value of the physiological terms in the derivational view.

Finally, model-reduction is presented here as an epistemological tool that relates theories in one discipline to models in a lower-level discipline. Models are discussed here in the context of being a reductive tool that facilitates enquiry about hidden generative mechanisms by modelling the unknown process on a known source derived from a lower-level discipline.

CHAPTER SIX

Conclusion

The issue of reductionism in psychology is one which traditionally examines the feasibility of reducing one science to a lower-level science in order to ground a scientific explanation in a realm that is seen as more basic or more real in terms of a hierarchy of sciences. Until the latter part of the twentieth century, a science such as physics or chemistry had a better grasp on reality due to being seen as more fundamental, general, simple and more widely applicable than the higher-level sciences.

The *zeitgeist* of post-Newtonian science encouraged a way of looking at the world that sought explanation in the material world, transferring much of the causal control of worldly phenomena away from deities and celestial powers and into the the same material world as the phenomena. The traditional reductive route in psychology has been to the next lower science on the hierarchy, physiology. Physiological explanations for psychological phenomena are sought by investigation of the biological unit, through measurement and manipulation of the physiology. This thesis has concentrated on neurophysiology as the reductive application in psychology, following the popular notion that it at least mediates many psychological phenomena, although reductionism in psychology can involve any bodily structure or process in a psychological explanation.

Although the reduction to physiology in psychology is predicated on an assertion of general identity between psychological and physiological states, Chapter Two concentrated on the content of the lower-level investigations rather than with the identity relation. The basic unit of analysis in Chapter Two was the singular neuron and its all-or-none action, an action that has helped researchers to isolate specific areas with regard to psychological processes and enable function to be attributed to the physiological apparatus. This, (as was seen towards the end of Chapter Five) is a somewhat simplistic notion of neurons, as they can have thousands of inputs, graded thresholds and graded responses. This leaves the basic binary action of the neuron as an increasingly arbitrary unit of analysis with regard to explanation. The convenience of this unit of analysis may not be able to continue to drown out the anomalous questions arising of an atomistic nature, such as can the "impoverished neuron" provide a

good model of psychological phenomena without recourse to yet more minute entities that make up the structure of the neuron? This is an example of the regressive trap that reductive researchers fall into.

This sort of regress is constantly ready to trap the researcher who employs reductionist methods that investigate the target level. The convention that arises in many sciences is to regress one level to the next lower discipline, but since this discipline is apparently composed of even smaller component disciplines, the regress is too much for the researcher to continue with, probably through having been trained in only one discipline. Consequently the regression is halted at (as with the neuron example above) an arbitrary level with regard to explanation and the atomistic philosophy of the reductionist.

The global approach which measures gross levels of brain structure can be seen as an arbitrary attempt to avoid ever decreasing indeterminacies within the brain, and also to a relative extent is an approach that avoids the problem of the measuring equipment interfering with the process of brain activity, a problem which increases as the size of the unit of analysis gets smaller. Also, the example of the observer being part of the subject matter (i.e. a psychological being) presents a reflexive problem which was beyond the scope of this thesis.

Chapter Three examined the concept of explanation in psychology, and considered the explication of causal relations to be a key objective of the explanatory search in psychology. Theory is represented as the vehicle though which causal explanation is sought, following a realist approach that sees all knowledge as theoretical, but also assumes the existence of a real world. Chapter Three also provided an attempt to represent causation as description. This links explanation with description in the reductive mode, as an account of physiological determinants constitutes an explanation in reductionist circles. The biological organism is seen to mediate cause and effect, leading to explanation constituting a descriptive, reductive account. Reductionism is also interpreted as a kind of theoretical framework that sets the parameters of enquiry and ignores anomalous results through a faith in technology.

Chapter Three provided some points that tempered the discussion on reductionism that followed. These included:

1) Must an explanation for everything be sought?

2) Given that the realist distinguishes between theories and an assumed ontological (worldly) reality, how does the unavoidably theoretical outlook enable the realist to know about the worldly reality, apart from the fact that we have theory as its representative?

3) The partial causation account of causality points out that the definition of a cause is restricted to controllable factors. The smaller the unit of analysis, the more con-

trollable are the factors.

4) The reductive framework sets parameters on the unit of analysis that help perpetuate the framework.

An analysis of levels of science continued the theme of explanation in science and explored the different levels of science from which a causal explanation can be sought. This was done by way of a discussion of levels of science, and the hierarchy of sciences was introduced as a list running from lower-level sciences such as physics and sub-atomic physics through to psychology and sociology. From top to bottom, this hierarchy of sciences lists disciplines of increasing generality and applicability as the unit of analysis gets smaller. The lower-level sciences are seen here to comprise at least part of the subject matter of the higher-level sciences. The reductive tradition holds that the lower levels can in fact be built up to comprise the higher levels of science. Two points are salient here:

1) The reductive tradition goes some way to actually dissolving interdisciplinary barriers.

2) Indeterminacies starting at the sub-atomic level may be amplified with increasing levels of the hierarchy.

A discussion of three directions for the explanation to be sourced then followed: top-down explanations explain with reference to higher-level sciences - in psychology this tends to lose touch with the individual and possibly deny the agency that some would see as important to retain in an explanation. Also, top-down explanations do not provide causes which are controllable - blaming for example the structure of society for deviant behaviour leads to few manipulable variables being presented, and such an explanation does not cohere with an individualistic legal system. This echoes the partial causality account of "causes" being restricted to controllable levels for pragmatic reasons.

Within-level explanations or causal sources carry a certain explanatory simplicity that does not require arbitrary restrictions on the size of the unit of analysis, a unit which becomes ever smaller at each level of science. They also help to retain the identity of a given discipline by keeping to the home terminology.

Bottom-up explanations are covered in detail throughout this thesis, and constitute the essence of reductionism. Reduction in psychology can also occur with recourse to disciplines that are not ordered in such a linear hierarchic fashion as with psychology and physiology. The use of models in psychology (Chapter Five) can use disciplines such as micro-economics, linguistics, computing or mechanics to provide source-knowledge and reduce psychology to them. The direction of the reduction (upwards, downwards or sideways) is then in some doubt if psychology and the model-source discipline are not able to be hierarchically

ordered. A "single concept" is considered here to be reductive regardless of the level of complexity of the source discipline.

A hierarchy of systems was introduced in Chapter Four to refer to the worldly systems and processes that the hierarchy of sciences theorise about. The hierarchy of systems is represented here by an inverted tree, in which the generalised higher systems act downwards as precursors of more highly specialised but more widely distributed activity in lower-level systems. The hierarchy of systems, from Koestler (1967) applied to psychological material helps to elucidate levels of systems within the psychological beast, and points to flow-down effects that start with such things as ideation and end with such things as low-level motor behaviour. The point is that the generalised "commands" at the top of the hierarchy trigger or control more specialised systems at lower levels without having to represent the detail of the lower-order systems. This concurs with the "downward causation" approach mentioned in Chapter Five, which sees the higher-level world as determining the distribution of the lower-level events and substances. This sort of downward determination appears diametrically opposed to reductionist determination which could be re-termed "upward determination".

The analytic outlook endorsed here is a twin-aspect perspective that sees a given unit of analysis as both a whole in itself and also part of a larger system. The reductive information gleaned from lower level systems by lower-level sciences can contribute, as seen in Chapter Five, to a derivational view of reduction that seeks to localise function or involve physiology in a psychological explanation. By setting stringent requirements for the relation of physiological to psychological terms, the analysis does not stray too far from what reductionists would call the underlying physiological realities.

The eliminative view of reduction which attempts to replace psychological explanations with physiological explanations is not taken here as plausible due to the inability of the psychological terms to translate between sciences and keep their meaning and higher-level context. Another reason for rejection of the eliminative view is a reluctance to change disciplines - following a rejection of the increased ontological status of lower level disciplines in the light of the indeterminacies outlined in Chapter Four.

Individualism and reductionism are two closely related terms, since individualism can be considered a form of reductionism. In sociology, individualism *is* the reductionist problem, since individualistic psychology is the next lower discipline on the hierarchy. In psychology however, individualism is widely accepted as non-reductive by those who see the biological unit and its inputs as providing all the potential information for good explanation. It is contended here however, that the individualistic outlook fails to account for transpersonal and intergroup behavioural monotony, and thus lacks the explanatory power to account for

social phenomena that are seen as important to psychology.

Incidentally, the non-individualistic outlook endorsed in this thesis has seen reductionism as a "social force" that is not reducible to the attitudinal states of the scientists who practice it. Although mention is made of the "reductionist" researcher, it is not the intention to attribute blame for the reductive paradigm to the reductive scientist. Reductionism is seen here as a pervasive force in society that transcends the individualist paradigm, and could require sociological, economic or political analysis to be fully understood.

The distinction between systems and theories implied in Chapter Three in a realist context and introduced formally in Chapter Four was extended in Chapter Five to register a distinction between "process" and "theory" autonomy. The distinction attempts to show that the autonomy or *irreducibility* of higher-level processes does not follow from the fact that theories may not be reducible - due to differences in the conceptual structure of theories. This retains a faith in the fact that the world may still be ordered in a reductionistic, upwardly determinative fashion. Thus the inability of theory to penetrate the systems of the world means that we cannot eliminate the possibility that the levels of systems in the world are determined as per the reductive paradigm.

With this qualification in mind, the twin perspective outlined here firstly avoids to a certain extent the globalist excesses of a top-down approach that loses touch with agency, and secondly still takes advantage of the beneficial results of individualistic and within-level analysis. Also, some cognisance of the reductive contributions in psychology should enable correlation with physiological-level phenomena that prevents the physiological facts from being contradicted. However, given the extended time-frame that research following a downwardly determinative outlook would require, it is quite possible that the bottom-up contributions from physiology would pale into insignificance in the light of the non-personal ideas that "flow down" from higher levels of organisation at the political, sociological or macro-economic levels.

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